. ATENT COOPERATION TREATY

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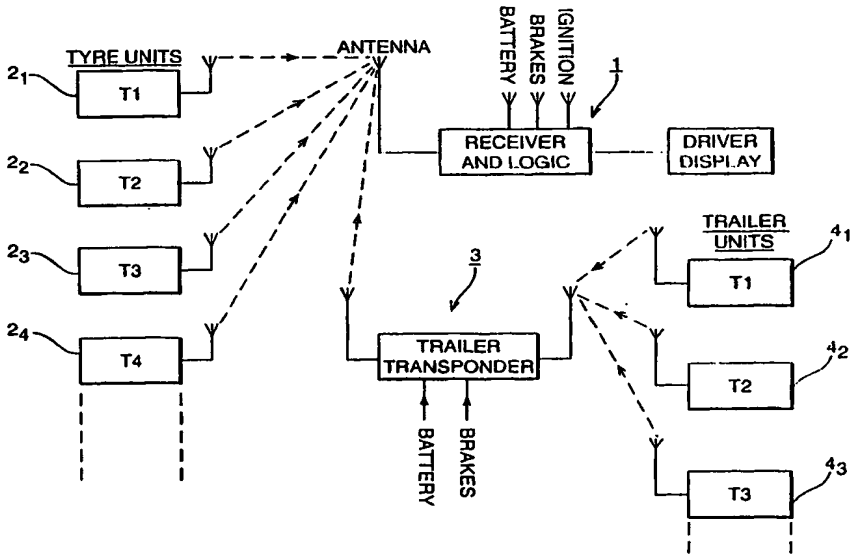

(57) Abstract

The present invention provides a battery-powered tyre pressure sensor including a pressure transducer (10) for sensing a pressure of a tyre and providing a tyre pressure signal. The tyre pressure sensor is arranged to transmit the signal containing information about the tyre pressure of an associated vehicle tyre to a cab unit (1) via a transmitter (13) where it is displayed to a driver of the vehicle. The pressure sensor monitors the pressure of the tyre and provides the vehicle driver with early warning of any deflation, thereby improving safety as well as reducing tyre wear and improving fuel economy. A timer (19) is included to turn the tyre pressure sensor off when it is not in use to conserve battery power.

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A REMOTE TYRE PRESSURE MONITORING SYSTEM

Field of the Invention

The present invention relates to a system for monitoring the pressure of tyres in a wheeled vehicle. In particular, the invention relates to a tyre pressure monitoring system employing individual battery-powered pressure sensors associated with each tyre for transmitting coded information to a receiver mounted within the vehicle to provide information about the condition of the tyres to a driver of the vehicle.

Background to the Invention

It is well known that for commercial vehicles even a small deviation from the correct tyre pressure can adversely affect tyre wear and substantially increase the fuel consumption of the vehicle. Constant under inflation can reduce a tyre's life by up to 50%. A worn commercial tyre which is in every other sense in good condition can usually be retreaded twice. However, once the tyre walls are damaged through under inflation this is not possible. Furthermore, the majority of "blow-outs", tyre shredding and vehicle fires are caused by tyre under inflation. As a result, many large vehicle fleet operators spend significant sums on checking tyre pressures regularly. Most of this would be rendered unnecessary by a reliable automatic pressure monitoring system.

Summary of the Invention

According to a first aspect of the present invention, a battery-powered tyre pressure sensor comprises:

a pressure transducer for sensing a pressure of a tyre and providing a tyre pressure signal;

a transmitter:

a signal processor connected to the pressure transducer for providing a signal dependent on the tyre pressure signal to the transmitter:

a timing circuit connected to the signal processor which is configured to automatically switch the tyre pressure sensor on periodically for a predetermined interval to measure the tyre pressure and switch off the tyre pressure sensor at all other times to conserve battery power, in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval.

The tyre pressure sensor of the present invention is suitable for all types of vehicles, but is especially suited for fitting to commercial vehicles such as buses, coaches, trucks, and lorries. The pressure sensor monitors the pressure of a tyre and gives the vehicle driver early warning of any deflation, thereby improving safety, as well as reducing tyre wear and improving fuel economy. An important aspect of the present invention is that the pressure sensor is only switched on periodically under the control of a timer to sample the tyre pressure. This feature allows battery power to be conserved and therefore effectively extend the life of the battery or otherwise allow a smaller battery to be used.

Preferably, the pressure sensor further comprises a non-volatile memory device for storing an identification code used to identify transmissions from the pressure sensor. Preferably, the non-volatile memory device also stores calibration information which is used to determine an accurate tyre pressure. In particular, during manufacture each pressure sensor may be tested at atmospheric pressure, maximum rated pressure, and at several points

between. and the results of the calibration routine stored in the non-volatile memory device as variables which characterize the response of the pressure sensor. The advantage of a non-volatile memory is that data is not lost when the pressure sensor is switched off in the interval between pressure measurements.

Preferably. the sensor unit further comprises a temperature transducer connected to the signal processor to provide a temperature signal to the signal processor. wherein the signal processor is adapted to apply a temperature compensation to the tyre pressure signal in dependence on the temperature signal. This feature allows the signal processor to correct the output of the pressure transducer to ensure accuracy over a range of. for example. -40°C to +60°C. In addition. if the air temperature falls below say 3°C. this information can be transmitted by the pressure sensor to warn the vehicle driver that road conditions may be hazardous.

Preferably. the signal processor is a microcontroller having an embedded computer program for controlling the operation of the pressure sensor. Preferably, the microcontroller is configured to record battery voltage and operating temperature each time it makes a pressure measurement and. when necessary, encode this information together with the pressure sensor identification code for transmission via the transmitter.

Preferably. the transmitter comprises a surface acoustic wave (SAW) resonator. Suitable radio frequencies for use in the United Kingdom include 418 MHz and 433 MHz in accordance with the radio specifications for MPT 1340 of the Radio Communications Agency. These frequencies are currently licence exempt.

In a preferred example of the present invention, the pressure sensor is adapted to be screwed onto the valve stem of a vehicle tyre. This allows the pressure sensor to be retro-fitted to existing vehicles. As an alternative, the pressure sensor may be adapted for mounting within a vehicle tyre.

Preferably, the pressure sensor is configured so that it does not make any transmissions until it is connected to an inflated tyre. This feature ensures that battery power is conserved during transport and storage of the pressure sensor before fitting to a tyre.

According to a second aspect of the present invention, a remote tyre pressure monitoring system for mounting on a vehicle comprises a plurality of tyre pressure sensors according to the first aspect of the present invention in combination with a cab unit for mounting within the vehicle cab, the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors: and,

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

According to a third aspect of the present invention, a transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre, the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors:

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location: and.

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

The transponder unit of the present invention allows a cab unit within a vehicle cab to distinguish between transmissions from the remote tyre pressure sensors of a trailer and other pressure sensors without requiring the driver to individually register each pressure sensor of the trailer whenever the vehicle cab and trailer are first connected. This is useful since a lorry driver may change trailer frequently. The cab unit within the vehicle cab is able to "learn" the unique identifier for the trailer transponder unit so that it can recognise subsequent transmissions forwarded by the transponder unit which encode information from the tyre pressure sensors connected to the trailer tyres.

According to a fourth aspect of the present invention, a remote tyre pressure monitoring system comprises a transponder unit according to the third aspect of the present invention in combination with a cab unit, wherein the cab unit comprises:

a receiver for receiving the coded signal from the transponder unit:

a signal processor for detecting and decoding the coded signal: and.

a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

Preferably, the remote tyre pressure monitoring system comprises a vehicle trailer on which the transponder unit is mounted.

Preferably, the remote tyre pressure sensors are tyre pressure sensors in accordance with the first aspect of the present invention.

The present invention combines simplicity of operation with the most advanced solid-state electronic design. It is proposed that the valve dust cap for each wheel of a vehicle is replaced by a pressure sensor in accordance with the present invention which monitors the tyre pressure and reports to a computer controlled unit in the vehicle cab. Should, for example, the pressure in any tyre drop by more than say 12.5%, a radio signal is then sent to a display in the cab to warn the driver as to which of his tyres is losing air. The driver then has time to act before the tyre is damaged, thereby saving on tyre wear and fuel, and perhaps avoiding the expensive results of complete tyre failure. It is also intended that the driver should be warned if any pressure sensor is suffering from low battery power or is missing or malfunctioning in any other way. Furthermore, if the air temperature at road level approaches freezing point the system warns of possible road icing. For articulated rigs, a radio transponder unit mounted on the front of the trailer relays messages from pressure sensors connected to the trailers wheels to the vehicle cab. With aerials and cabling supplied, the system of the present invention is as easy to fit as a car radio. In addition, there is nothing to connect or disconnect when changing trailer. The cab unit is pre-programmed to accept the new set of trailer wheels but will not respond to pressure sensors from other rigs.

An important aspect of the present invention is that the pressure sensors have a long life, typically up to three years. This is achieved by the use of the timing circuit which ensures that the pressure sensor is switched off most of the time. Typically, each pressure sensor

will draw a current of significantly less than 1 μA between pressure measurements. and draw only a small current of the order of 4.5 mA when switched on.

The present invention will lead to significant savings in running costs for commercial vehicle operators; savings within the first year which should represent four times the purchase price. Added to this are the safety advantages. greater reliability. and reduced levels of tyre maintenance.

Brief Description of the Drawings

Examples of the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of a tyre pressure monitoring system according to the present invention:

Figure 2 is a block diagram of an example of a tyre pressure sensor for use in the tyre pressure monitoring system of Figure 1:

Figures 3 shows a circuit implementing a temperature transducer. a pressure transducer and a reference voltage generator for use in the tyre pressure sensor of Figure 2:

Figure 4 shows a timing circuit implementing a timer and switch for use in the tyre pressure sensor of Figure 2;

Figure 5 shows an example of a transmitter and antenna circuit for use in the tyre pressure sensor of Figure 2:

Figure 6 shows an example of a non-volatile memory device for use in the tyre pressure sensor of Figure 2:

Figure 7 shows an example of a microcontroller for use in the tyre pressure sensor of Figure

2:

Figure 8 is a flow chart showing the sequence of operations for a calibration routine:

Figure 9 is a flow chart showing the sequence of operations for a tyre pressure measurement routine:

Figures 10 and 11 show a cab unit for use in the tyre pressure monitoring system of Figure 1: and.

Figure 12 is a block diagram of a transponder unit for use in the tyre pressure monitoring system of Figure 1.

Detailed Description

Figure 1 shows an example of a tyre pressure monitoring system according to the present invention. The system is suitable for mounting on the tyres of a vehicle such as a truck. bus. or coach. and also on lorries which have a vehicle cab (tractor) and a separate trailer. As shown. the system includes a cab unit 1 and a first set of tyre pressure sensor units 2_1 to 2_2. When applicable. the system includes a trailer transponder unit 3 and a second set of tyre pressure sensor units 4_1 to 4_3 associated with a trailer.

As will be described below. each of the sensor units 2_1 to 2_2 and 4_1 to 4_3 has a radio transmitter for transmitting a coded signal which carries information relating to the condition of a respective tyre to a receiver in the cab unit 1. The information is used to inform the vehicle driver about the pressure and temperature of each of the tyres by way of an audio/-visual display forming part of the cab unit 1. The transponder unit 3 is designed to be mounted on a lorry trailer and it detects transmitted signals from each of the second set of sensor units 4_1 to 4_3 associated with respective tyres of the trailer. The transponder

unit 3 transmits a coded signal to the cab unit 1 containing information about each of the trailer tyres. The cab unit 1 is adapted to decode the transponder signal and distinguish between the transponder signal and any other signal so that the driver can be alerted of any fault that has occurred in relation to any of the tyres on the lorry trailer as well as the cab.

Figure 2 shows a schematic representation of an example of a battery-powered tyre pressure sensor in accordance with the present invention. The pressure sensor comprises a pressure transducer 10, a temperature transducer 11, a reference voltage generator 12, a transmitter 13 and a non-volatile memory device 14, all connected to a microcontroller 15. The device also houses a battery 16 as the power supply. The pressure sensor is periodically activated by a timing circuit 17. The timing circuit 17 comprises a switch 18 and a timer 19. The timer 19 is configured to cause the pressure sensor to sample periodically the pressure of the tyre to which the device is connected, but otherwise disconnect the other elements of the pressure sensor from the battery 16 at all other times to conserve battery power. Finally, a calibration switch 20 is provided to calibrate the pressure sensor before shipping, as will be described below. The pressure sensor is implemented on a printed circuit board and, together with the battery, sealed with a housing adapted to be screwed onto a tyre valve stem.

The pressure transducer 10 is arranged to measure the pressure of the tyre and provide an output (PRESSURE) to the microcontroller 15. A suitable device is a piezo-resistive sensor, the resistivity of which changes with changes in pressure. An example of a suitable circuit which implements a pressure transducer is shown in Figure 3.

The temperature transducer 11 is configured to measure the temperature of the air surrounding the sensor and provide an output (TEMP) to the microcontroller 15. This output signal is used to provide a temperature compensation to the pressure signal output from the pressure transducer 10 so that an accurate pressure reading can be derived for comparison with a reference value stored in the non-volatile memory device 14 (which is obtained when the pressure sensor is first connected to a tyre - the tyre having been previously correctly inflated). The temperature signal may also be used to provide a driver of the vehicle with information about related driving conditions. An example of a suitable circuit which implements a temperature sensor is shown in Figure 3.

The reference voltage generator 12 is configured to generate a stable reference voltage signal (VREF) which is provided as an input to the microcontroller 15. The microcontroller 15 compares the reference voltage with the battery voltage (VOLTS) and generates an output signal dependent on this comparison. If the battery voltage is less than the reference voltage this means that a new battery is required and a signal is generated to convey this to the driver. Furthermore, in this event, the frequency of the sampling of the tyre pressure may automatically be reduced to prolong the life of the battery until a new pressure sensor or battery can be fitted. An example of a suitable circuit which implements a reference voltage generator is shown in Figure 3.

As described above, the timing circuit 16 comprises a switch 18 and a timer 19. The timer 19 runs all the time and periodically engages the switch 18 to start a pressure measurement cycle. At all other times the remaining components of the pressure sensor are switched off to conserve battery power. Furthermore, as described above, the frequency at which the

pressure sensor is switched on is dependent on the battery voltage. When this starts to fall, the microcontroller 15 generates a warning message in the next routine status transmission and at the same time reduces the sensor sampling frequency to conserve the remaining battery life. An example of a suitable circuit which implements the timer and switch functions is shown in Figure 4. The battery 16 is a lithium device having a diameter of 16mm with a rating of typically 60-70 mAh.

The function of the radio transmitter 14 is to send messages from each tyre pressure sensor to a receiver in either the cab unit 1 of the vehicle cab or in the transponder unit 3 of a trailer. For the United Kingdom, it is proposed that the transmitter 14 transmits the signal generated by the microprocessor 15 at a frequency of either 418 MHz or 433 MHz in accordance with the MPT1 340 specification. These frequencies are currently licence exempt. A suitable type of transmitter 15 is based on a surface acoustic wave (SAW) device. An example of a suitable circuit can be seen in Figure 5.

The non-volatile memory 15 stores information about the tyre and also contains a unique pressure sensor identification code, programmed during manufacture as part of a calibration process, as will be described below. One advantage of having a non-volatile memory device 15 in the pressure sensor is that when the sensor unit is switched off information is not lost. This is important since it enables power to be completely shut down to the main components of pressure sensor in the interval between sensor readings. An example of a suitable memory device is shown in Figure 6.

The microcontroller 15 accepts a signal from each of the pressure transducer 10, the

temperature transducer 11 and the reference voltage generator 12. It processes these signals and provides an output signal to the transmitter 14 which includes the unique sensor identification code for the pressure sensor. An example of a suitable microcontroller is shown in Figure 7. Each time the microcontroller 15 receives a signal from the pressure transducer 10 it also records the battery voltage and temperature. Thus, with the appropriate programming, it is able to determine an accurate pressure measurement for the tyre. The tyre pressure measurement is compared with a stored (notionally correct) reference value and if the tyre pressure is determined to deviate from this by a predetermined amount a message is generated by the microcontroller 15 for transmission. In addition to, or even in the absence of, any message relating to the condition of the tyre or driving conditions, the microcontroller 15 is arranged periodically to generate an identification message for transmission which serves to confirm that the pressure sensor remains operational. Failure to transmit such a message will eventually cause a warning to be displayed on the cab unit 1 to indicate to the driver that the pressure sensor has either failed or been removed.

A computer program is embedded within the microcontroller 15 which controls the operation of the pressure sensor. The computer program is executed when power is applied to the microcontroller 15 by the timing circuit 16, initiated by the timer 19. The computer program contains two distinct parts. One part executes during a calibration cycle and the other part executes at all other times. The microcontroller 15 decides which part to execute by examining the state of the MODE input pin (pin 7 in Figure 7). As shown in the pseudocode below and the flow chart of Figure 8, during calibration the MODE pin is initially set to a low state by a calibration jig (not shown). At all other times it is kept in a high state. Once calibration commences the MODE pin is used as a bi-directional path

for signals between the microcontroller 15 and the calibration jig.

START of PROGRAM

Carry out system initialising tasks

Read the status of the MODE pin

IF MODE pin is in low state THEN

    Execute Calibrate_Code

ELSE

    Execute Normal_Code

ENDIF

The pseudocode below and flow chart of Figure 8 detail the calibration procedure for a pressure sensor:

Calibrate_Code

Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at a low reference value. Provide a high excitation voltage to the pressure transducer, via OUTB of the D-A converter of the pressure transducer 10 (Figure 3). Adjust OUTA of the D-A converter to provide zero output between the pressure transducer outputs (OUT+ and OUT-).

Store the digital value required to achieve the zero output in the Non-Volatile Memory (Step XX).

Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at the high reference value.

Adjust OUTA of the D-A converter to provide a standard output between the pressure transducer outputs (OUT+ and OUT-).

Store the digital value required to achieve the standard output in the Non-Volatile Memory (Step YY).

Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at one of several intermediate pressure reference values. For each pressure step:

Using the calibration coefficients stored in Non-Volatile memory (Steps XX and YY above) calculate the expected pressure transducer output: and.

Measure the output of the pressure transducer and compare it with the calculated value.

Set a flag bit in memory to indicate agreement betweeen the measured and calculated values.

The MODE pin is driven by the calibration jig (not shown) which provides manufacturing date code. the identification code for the unit. an initial reference pressure of zero. multi-count value. percentage pressure band limits. battery condition flag and other information that may be required to be stored. This data is routed to and stored in the non-volatile memory.

The pseudo code below and flow chart of Figure 9 details the normal operation of the pressure sensor:

```
Normal_Code
Recover the value of the Reference Pressure from the Non-Volatile Memory.
IF the stored Reference Pressure is zero THEN
    Recover the pressure calibration coefficients from the Non-Volatile Memory.
    Read the temperature transducer to determine the current temperature.
    Read the current pressure and apply temperature corrections.
    If the corrected current pressure is less than a small figure (typically 2 PSI) THEN
        Do nothing
    ELSE
        Write the current pressure into a Reference Pressure location in the Non-
        Volatile Memory.
        Recover the unit identification code from the Non-Volatile Memory.
        Transmit the sensor identification code to the Cab Unit via the transmitter and
        antenna together with a message indicating that this is an initial transmission
        from the particular sensor. Repeat the transmission several times to increase
        the probability of correct reception by the Cab Unit.
    ENDIF
    Disable the Power Switch (Sleep)
ELSE
    Recover the multi-count value from Non-Volatile Memory
    IF the multi-count is not zero THEN
```

Recover the current cycle-counter value

IF the value of the cycle-counter is not zero THEN

Decrement the cycle-counter value

Write the cycle-counter value back into Non-Volatile Memory

Disable the Power Switch (Sleep)

ENDIF

ENDIF

ENDIF

Recover the battery low flag from Non-Volatile memory

IF the battery low flag indicates a healthy battery THEN

Write the multi-count value into Non-Volatile Memory to initialise a new count down sequence.

ELSE

Write an increased multi-count value into Non-Volatile Memory to initialise a new larger (battery conserving) count down cycle.

ENDIF

Recover the calibration coefficients from the Non-Volatile Memory.

Send the calibration coefficients to the D-A converter where they will be converted to voltages at OUTA and OUTB.

Read the temperature transducer to ascertain the current temperature.

Set the temperature warning flag if the temperature is low enough to merit warning the driver that road conditions are becoming hazardous.

Read the current output from the pressure transducer circuit and apply temperature

corrections.

Recover the acceptable percentage band limits from the Non-Volatile Memory.

Compare the reference pressure with the pressure reading that has just been taken and corrected for temperature effects.

IF pressure is outside acceptable percentage limits THEN

Set a flag Pressure Warning flag

ENDIF

Determine the battery voltage using the voltage reference and potential divider.

Determine if the voltage is above a threshold that indicates a healthy battery.

IF the battery voltage check indicates that the battery is beginning to fail THEN

Set a battery-low flag into Non Volatile Memory.

ENDIF

Compose a message containing the sensor identification code, the result of the pressure check, the temperature flag and the battery condition.

Transmit the message to the Cab Unit via the transmitter and antenna together with a header indicating that this is a routine transmission.

IF the pressure reading was outside the acceptable percentage band limits THEN

Repeat the transmission several times to increase the probability of reception.

IF the pressure reading was zero THEN

Set the reference pressure stored in the Non-Volatile Memory to zero.

ENDIF

ENDIF

Disable the Power Switch (Sleep)

Figure 10 shows a schematic representation of an example of a cab unit 1 suitable for use in the tyre pressure monitoring system. The cab unit 1 comprises a receiving antenna 30, a microcontroller 31, a driver's display 32 to display information about the tyres to the driver, and a memory 33. The microcontroller 31 is able to distinguish between signals and identify, by way of its unique identification code, which pressure sensor or transponder unit is sending each signal. In normal operation, each pressure sensor periodically transmits an "all's-well" signal. If the cab unit 1 detects two consecutive missing signals from the same unit, an LED will flash to tell the driver to check that tyre. The cab unit 1 can display warnings whenever any tyre is suffering from any of low pressure, low temperature, low battery or a missing sensor unit. The drivers cab display 32 is shown in detail in Figure 11.

The drivers cab display 32 has the following items:

- a two digit wheel number indicator 40 with two small adjacent LED indicators. One LED illuminates when the wheel number displayed relates to the cab and the other illuminates when the wheel number relates to a trailer:
- further LEDs 41 to 44 provide "low temperature", "low pressure", "low battery", and "unit missing" warnings, respectively; and,
- a switch 45 with positions, LEARN CAB, LEARN TRAILER and NORMAL, with small LEDs to indicate a teaching process (to be described below) is being carried out.

An acoustic sounder (not shown) is included in the cab unit 1 and sounds for ten seconds

after a warning message is received and every five minutes thereafter. When the ignition is turned on the sounder makes a short chirp. If a warning message has been received during driver absence it will sound for ten seconds. Power is supplied continuously by the vehicle battery or via the ignition circuit. A "cancel" button (not shown) is also provided which can disable a warning entry until the next ignition off-on cycle.

Figure 12 shows a schematic representation of an example of a transponder unit 3 for a trailer. The transponder unit comprises a receiver 51, a microcontroller 52 and a transmitter 53. The receiver 51 periodically receives signals transmitted by individual tyre pressure sensors and couples the signals to the microcontroller 52. The microcontroller 52 processes a signal and generates a new message which incorporates a unique identification code associated with the transponder unit 3 as a header which is transmitted by the transmitter 53 and which can be detected by the cab unit. This identification code, as with the pressure sensors, is stored in a memory 54.

Referring to Figure 11 above, when fitting pressure sensors to a single vehicle or a cab, the driver selects the LEARN feature to indicate that pressure sensors are about to be installed on the wheels. The cab unit 1 then wipes out all stored information (if any) relating to previous wheels. The driver then walks around the vehicle fitting pressure sensors to each of the valves of the wheels in a predetermined order. Once fitted, a pressure sensor recognises it has lifted off from 0 psi and sends its identification code several times. After each pressure sensor is fitted the driver must wait for the cab unit 1 to sound to indicate that it has recognised the new sensor unit successfully before proceeding to the next wheel. After all the wheels have been fitted with a pressure sensor, the driver then selects the

NORMAL feature. At this stage the cab unit 1 now knows how many wheels are present and their identification codes, and the monitoring system is then ready for use.

When fitting pressure sensors to a trailer, the driver selects a corresponding LEARN TRAILER feature on the trailer transponder unit 3 (not shown). The driver then walks around the trailer in the same manner as for a cab unit, fitting each of the wheels in turn with a pressure sensor so that the trailer transponder unit 3 knows how many wheels are present and their identification codes. When the trailer is then connected to the vehicle cab, the driver selects the LEARN TRAILER feature on the cab unit 1 so that any previous information relating to trailers is deleted. After the ignition is turned on, when the brake pedal is first depressed the trailer transponder unit 3 recognises that it should identify itself to the cab unit 1 because this is the first time it has had power supplied and the brake light line is active. It then transmits its unique identification code to the cab unit 1 to identify itself as a new trailer. This identification code for the trailer is then stored in the cab unit 1. The driver subsequently selects the NORMAL feature and the system is now ready for use.

As an alternative, the "learn trailer" step can be automated so that the driver does not even need to select this on the cab unit - the registration process is carried out automatically after ignition is switched on.

The cab unit 1 receives transmissions from the cab's wheels, which are recognised, and trailer wheel messages which are ignored. The trailer transponder unit 3 receives transmission from its own wheels, which are recognised, and the cab wheels which are

ignored. As described above, information from the trailer wheels is stored in the trailer transponder unit 3 and warning and other messages from the trailer transponder unit 3 are relayed to the cab with a message header so that they are recognised by the cab. It is proposed that warning messages are passed to the cab immediately by the transponder unit 3 whereas routine "all's well" messages are only sent periodically.

It is possible to build on the tyre pressure monitoring system of the present invention to provide a complete tyre management system for a fleet operator. The idea is that as each vehicle returns to a depot, the cab unit is automatically interrogated to determine the condition of each tyre. The vehicle depot keeps a computer database which provides a record of the vehicle movements and a list of which tyres on which vehicles need attention. In this way, the need to rely on driver trip reports is reduced. The depot system could also be programmed to interrogate vehicles as they leave a depot as a double check that any defective tyres have been duly corrected.

CLAIMS

1. A battery-powered tyre pressure sensor, comprising:

a pressure transducer for sensing a pressure of a tyre and providing a tyre pressure signal;

a transmitter;

a signal processor connected to the pressure transducer for providing a signal dependent on the tyre pressure signal to the transmitter;

a timing circuit connected to the signal processor which is configured to automatically switch the tyre pressure sensor on periodically for a predetermined interval to measure the tyre pressure and switch off the tyre pressure sensor at all other times to conserve battery power, in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval.

2. A battery-powered tyre pressure sensor according to claim 1, further comprising a non-volatile memory device for storing an identification code used to identify transmissions from the pressure sensor.

3. A battery-powered tyre pressure sensor according to claim 2, in which the non-volatile memory device also stores calibration information which is used to determine the tyre pressure.

4. A battery-powered tyre pressure sensor according to any preceding claim, further comprising a temperature transducer connected to the signal processor to provide a

temperature signal to the signal processor, wherein the signal processor is adapted to apply a temperature compensation to the tyre pressure signal in dependence on the temperature signal.

5. A battery-powered tyre pressure sensor according to any preceding claim, in which the signal processor is a microcontroller having an embedded computer program for controlling the operation of the pressure sensor.

6. A battery-powered tyre pressure sensor according to claim 5, in which the microcontroller is configured to record battery voltage and operating temperature each time it makes a pressure measurement and, when necessary, encode this information together with the pressure sensor identification code for transmission via the transmitter.

7. A battery-powered tyre pressure sensor according to any preceding claim, in which the transmitter comprises a surface acoustic wave (SAW) resonator.

8. A battery-powered tyre pressure sensor according to any preceding claim, configured so that it does not make any transmissions until it is connected to an inflated tyre.

9. A battery-powered tyre pressure sensor according to any preceding claim, adapted to be screwed onto the valve stem of a vehicle tyre.

10. A remote tyre pressure monitoring system for mounting on a vehicle, comprising a plurality of tyre pressure sensors according to any preceding claim in combination with a

cab unit for mounting within the vehicle cab. the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors: and.

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

11. A transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres. wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre. the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors:

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location: and.

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

12. A remote tyre pressure monitoring system comprising a transponder unit according to claim 11. in combination with a cab unit. the cab unit comprising:

a receiver for receiving the coded signal from the transponder unit;

a signal processor for detecting and decoding the coded signal: and.

a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

13. A remote tyre pressure monitoring system according to claim 12. further comprising

a vehicle trailer on which the transponder unit is mounted.

14. A remote tyre pressure monitoring system according to claim 12 or 13, in which the remote tyre pressure sensors are tyre pressure sensors according to any of claims 1 to 9.

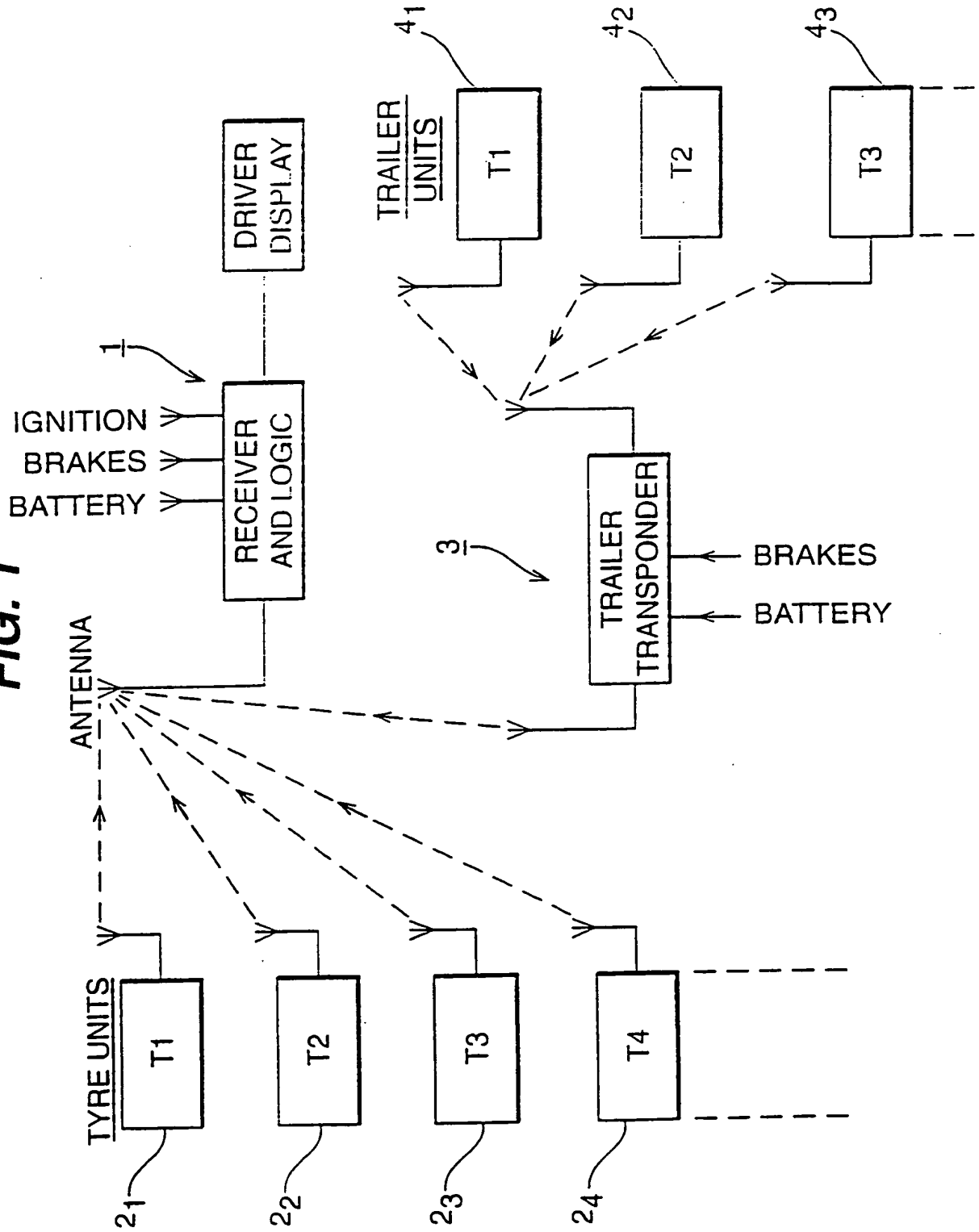

DRIVER DISPLAY
TRAILER UNITS
T1
T2
T3
41
42
43
1
IGNITION
BRAKES
BATTERY
RECEIVER AND LOGIC
3
TRAILER TRANSPONDER
BRAKES
BATTERY
ANTENNA
TYRE UNITS
T1
T2
T3
T4
21
22
23
24

FIG. 1

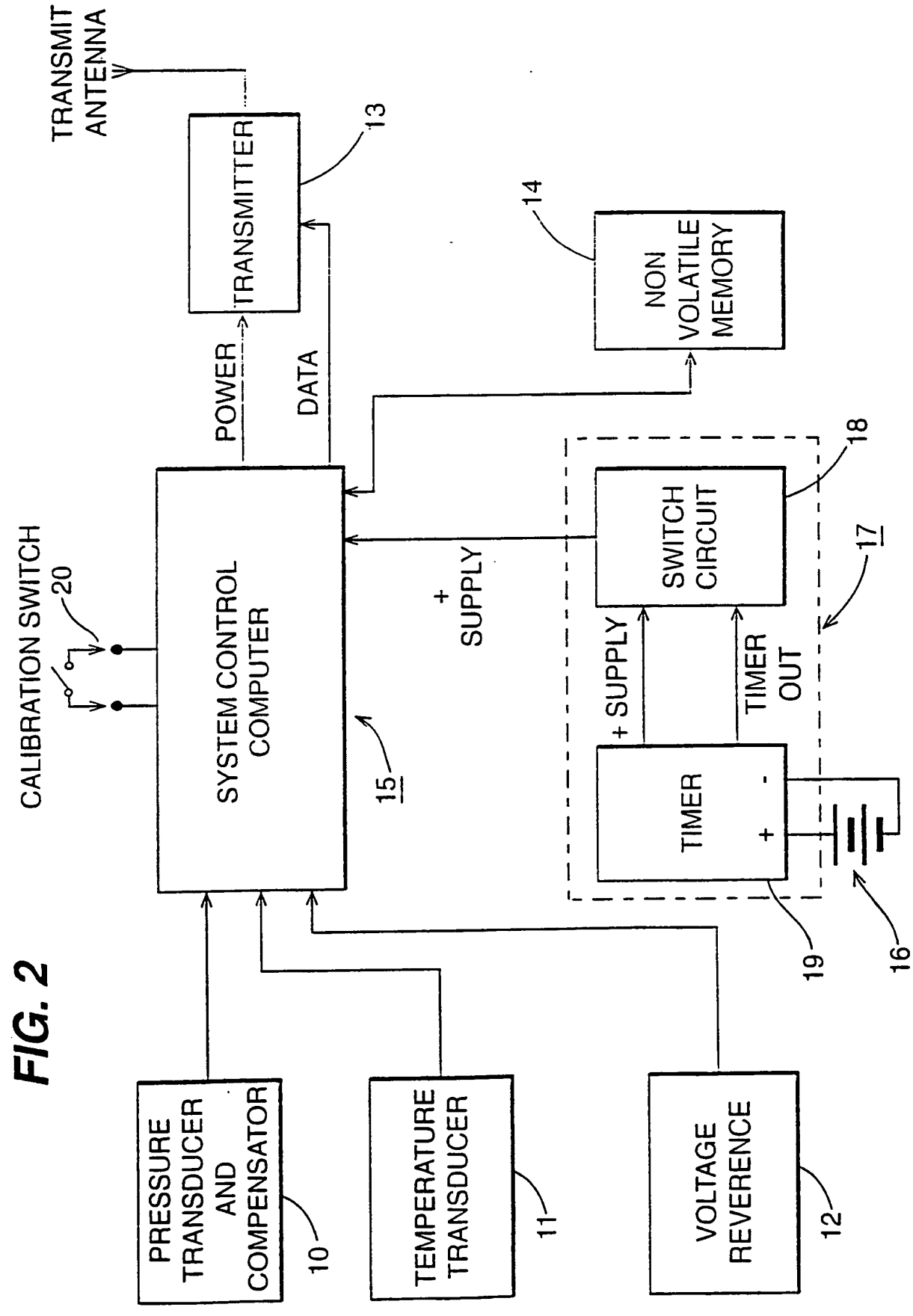

TRANSMIT ANTENNA
TRANSMITTER
13
14
NON VOLATILE MEMORY
POWER
DATA
18
SWITCH CIRCUIT
17
CALIBRATION SWITCH
20
SYSTEM CONTROL COMPUTER
15
+ SUPPLY
+ SUPPLY
TIMER OUT
TIMER
19
16
PRESSURE TRANSDUCER AND COMPENSATOR
10
TEMPERATURE TRANSDUCER
11
VOLTAGE REVERENCE
12

FIG. 2

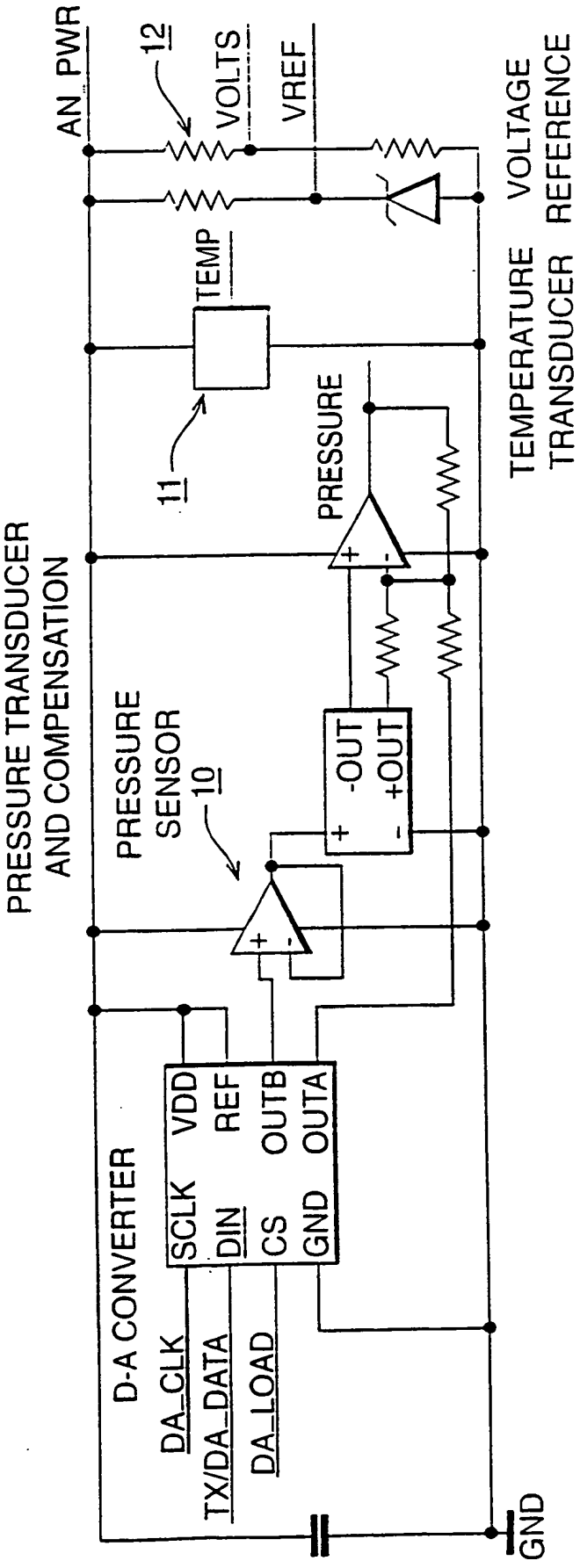

AN_PWR
12
VOLTS
VREF
VOLTAGE REFERENCE
TEMP
TEMPERATURE TRANSDUCER
11
PRESSURE
PRESSURE TRANSDUCER AND COMPENSATION
PRESSURE SENSOR
10
-OUT
+OUT
D-A CONVERTER
SCLK
VDD
REF
OUTB
OUTA
DIN
CS
GND
DA_CLK
TX/DA_DATA
DA_LOAD
GND

FIG. 3

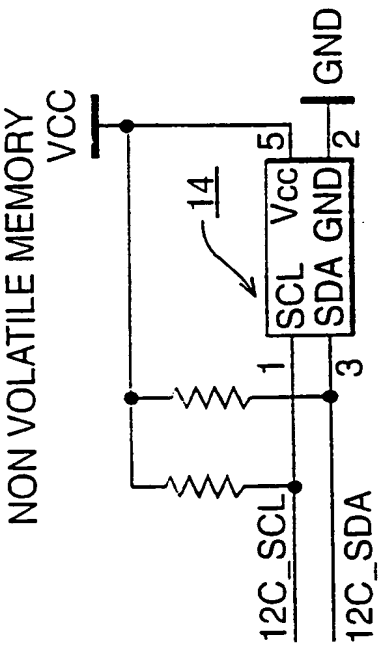

NON VOLATILE MEMORY
VCC
14
SCL
SDA
Vcc
GND
5
2
1
3
12C_SCL
12C_SDA

FIG. 6

FIG. 4

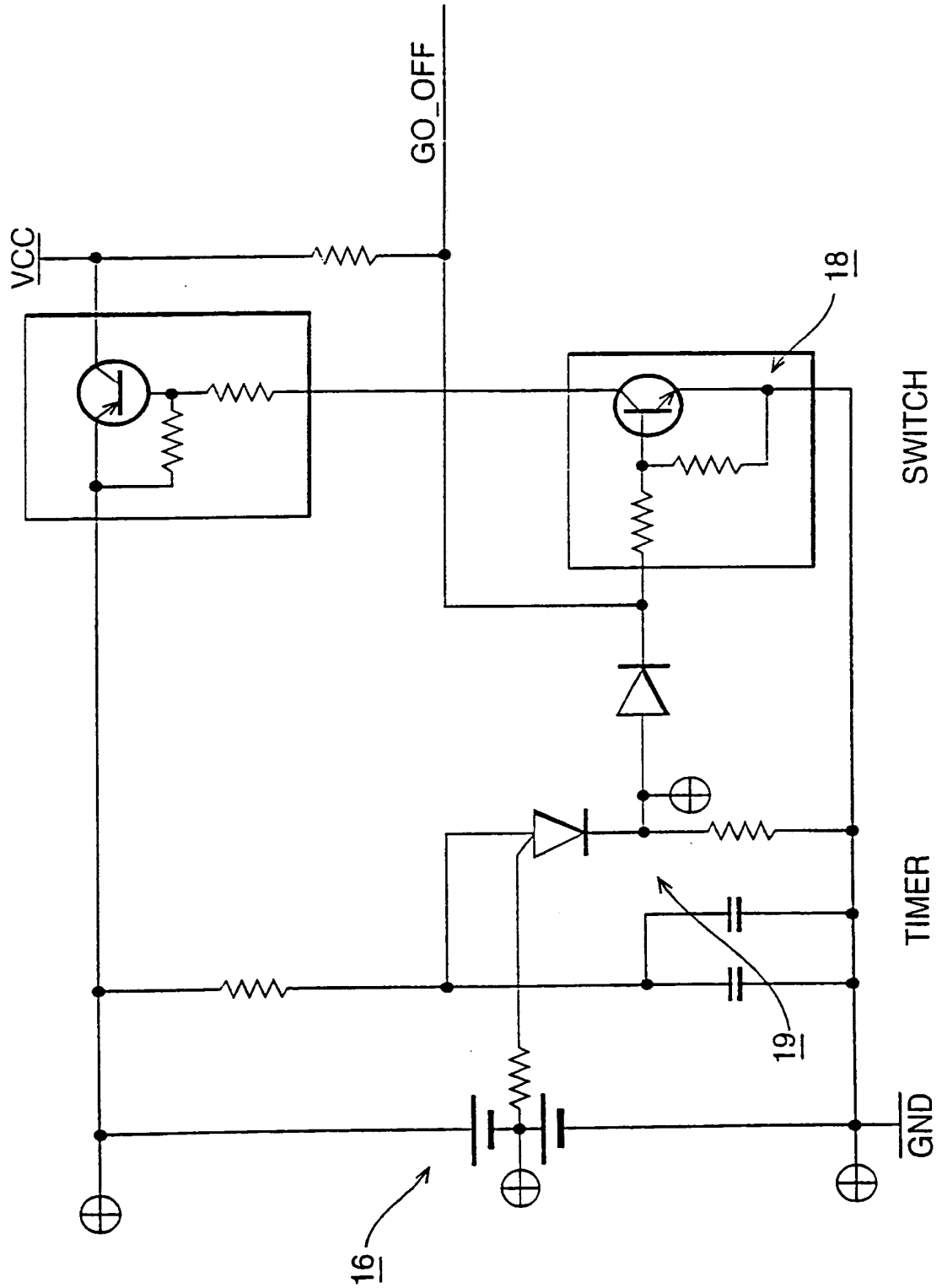


FIG. 5

TRANSMITTER AND ANTENNA

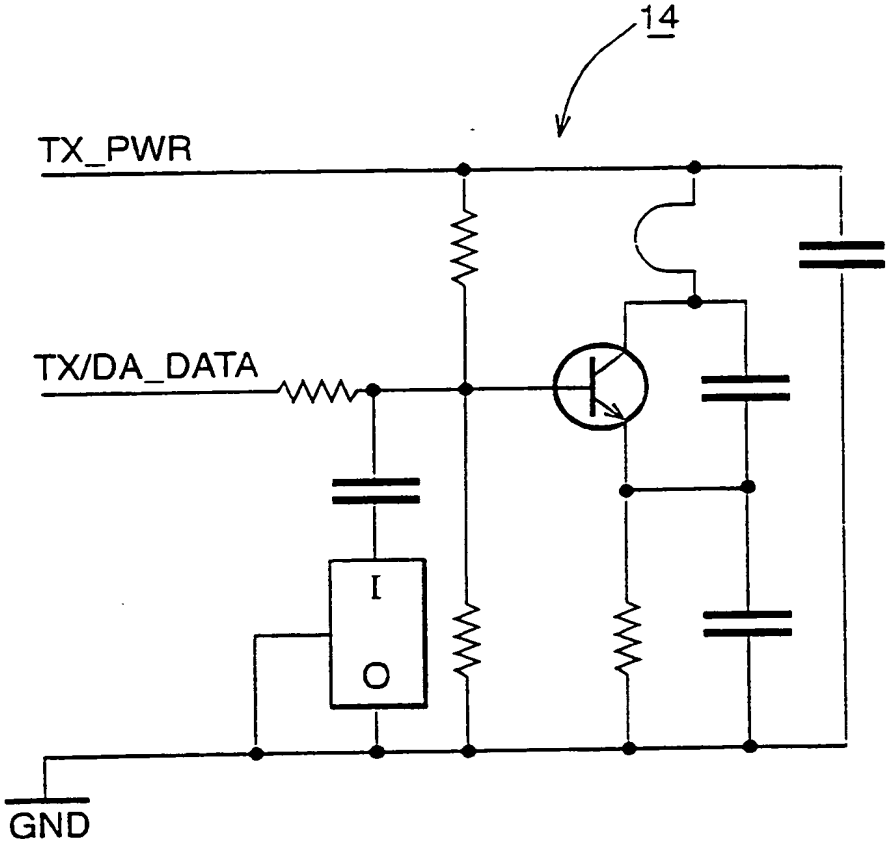


FIG.11

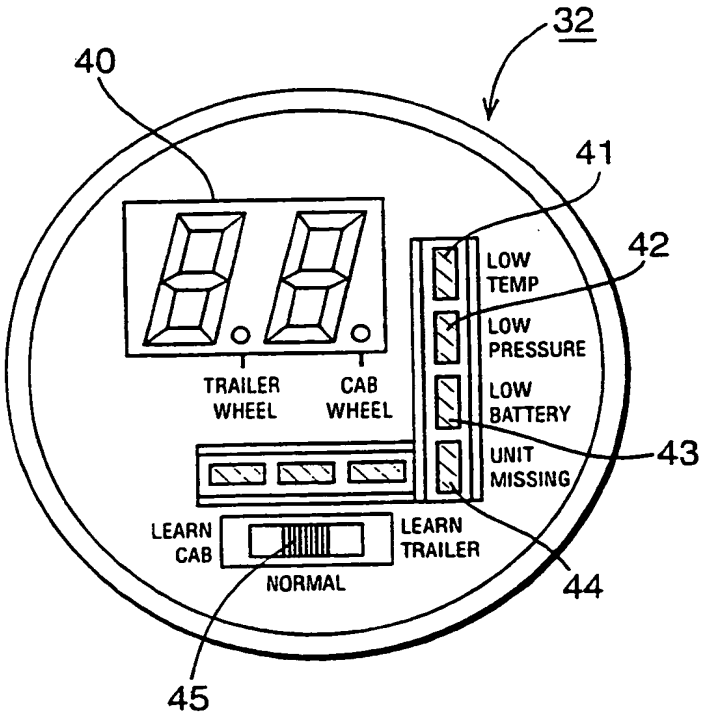


FIG. 7

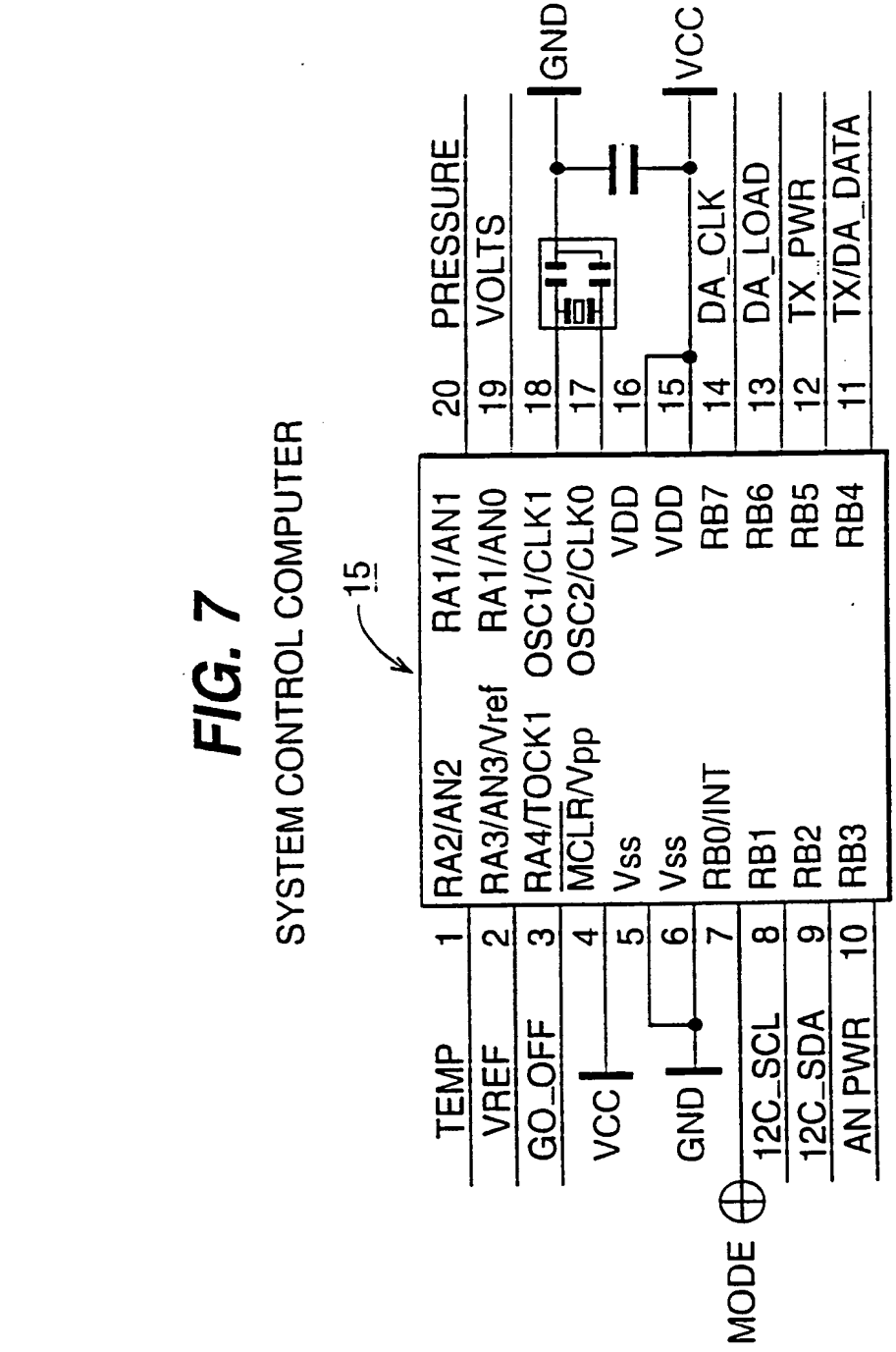
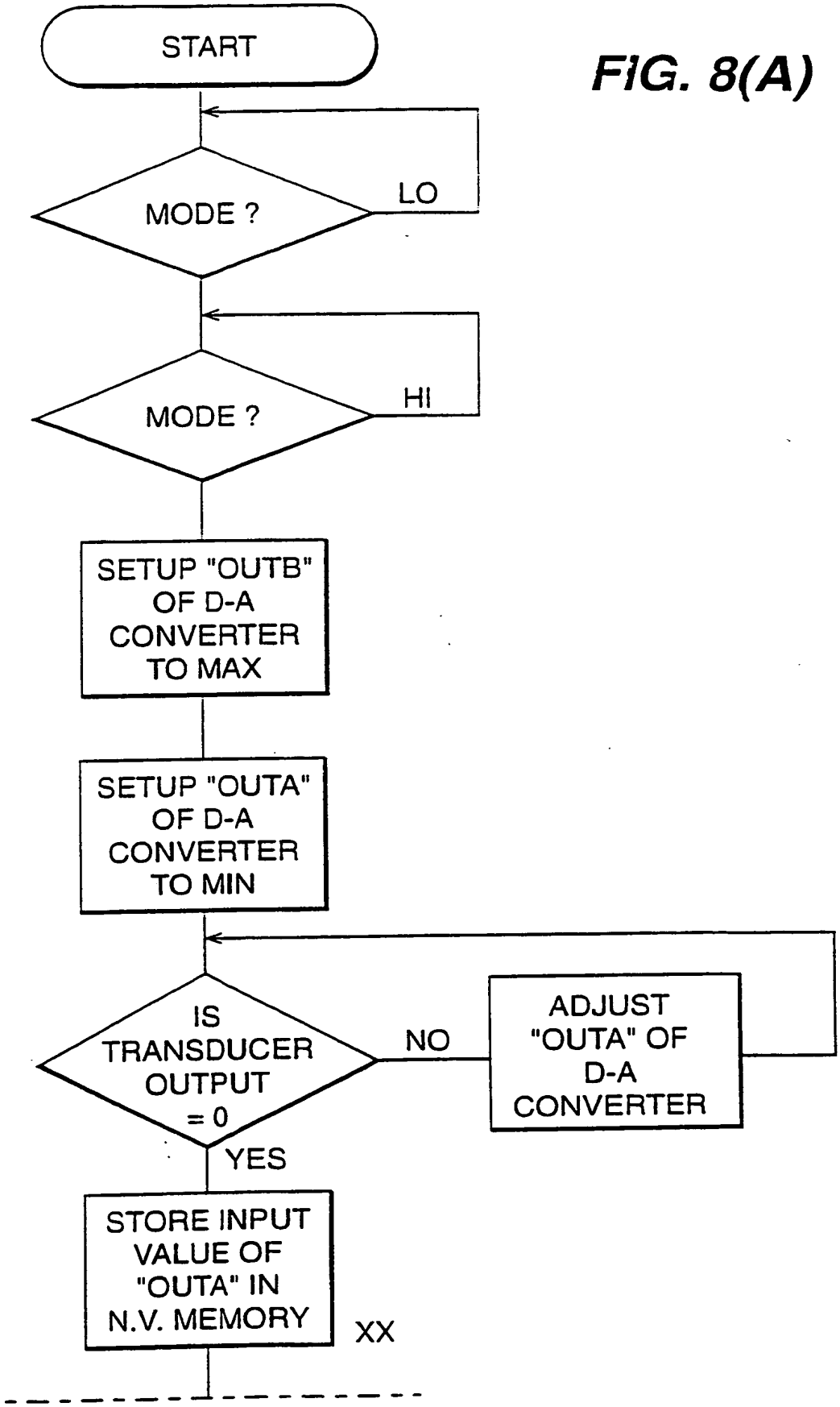

SYSTEM CONTROL COMPUTER
15
TEMP 1
VREF 2
GO_OFF 3
VCC
GND
MODE
12C_SCL 8
12C_SDA 9
AN PWR 10
RA2/AN2
RA3/AN3/Vref
RA4/TOCK1
MCLR/Vpp
Vss
Vss
RB0/INT
RB1
RB2
RB3
RA1/AN1
RA1/AN0
OSC1/CLK1
OSC2/CLK0
VDD
VDD
RB7
RB6
RB5
RB4
20 PRESSURE
19 VOLTS
18
17
16
15
14 DA_CLK
13 DA_LOAD
12 TX_PWR
11 TX/DA_DATA
GND
VCC

FIG. 8(A)


START
MODE ?
LO
MODE ?
HI
SETUP "OUTB" OF D-A CONVERTER TO MAX
SETUP "OUTA" OF D-A CONVERTER TO MIN
IS TRANSDUCER OUTPUT = 0
NO
ADJUST "OUTA" OF D-A CONVERTER
YES
STORE INPUT VALUE OF "OUTA" IN N.V. MEMORY
XX

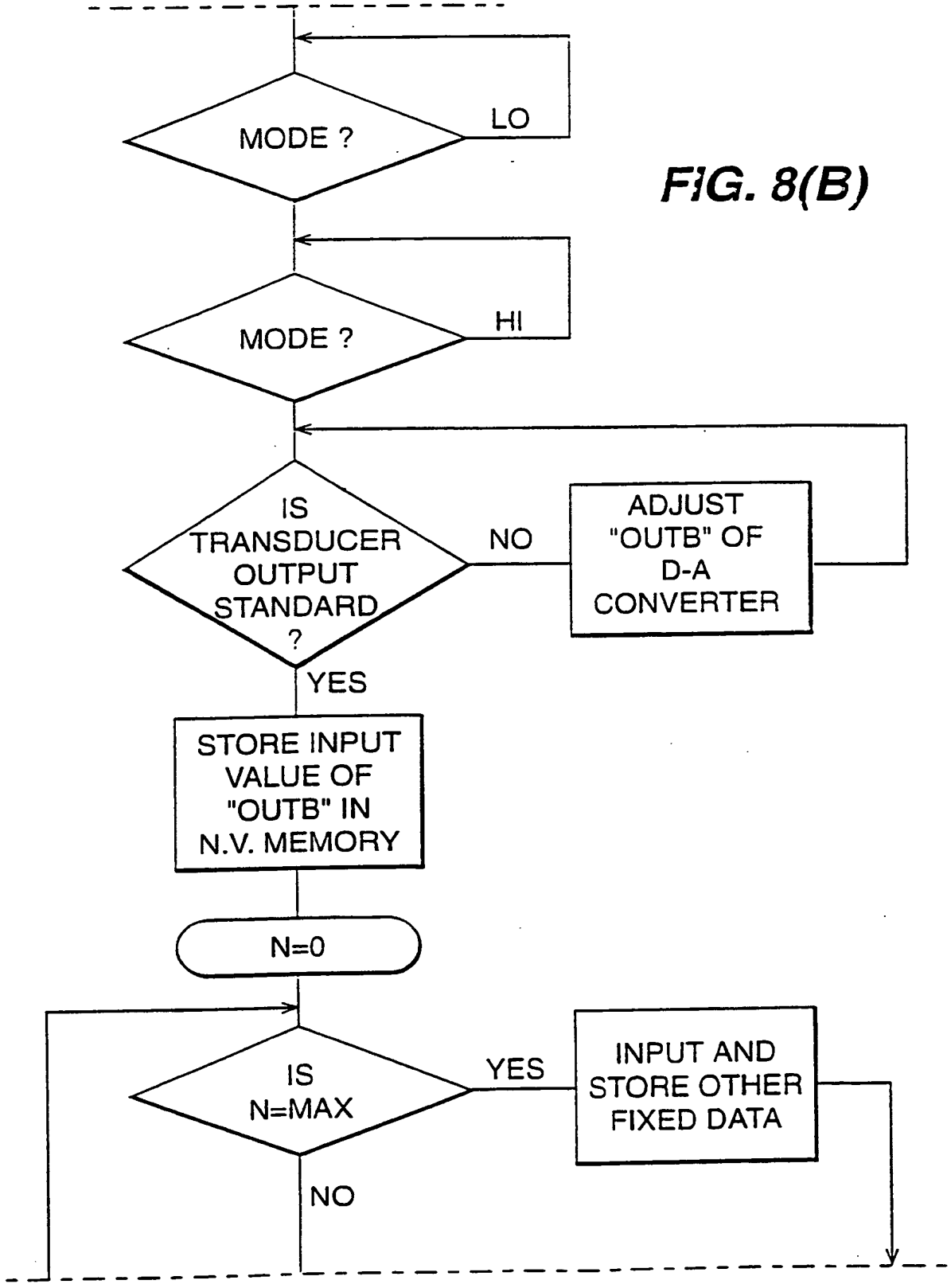

MODE ?
LO
MODE ?
HI
IS TRANSDUCER OUTPUT STANDARD ?
NO
ADJUST "OUTB" OF D-A CONVERTER
YES
STORE INPUT VALUE OF "OUTB" IN N.V. MEMORY
N=0
IS N=MAX
YES
INPUT AND STORE OTHER FIXED DATA
NO

FIG. 8(B)

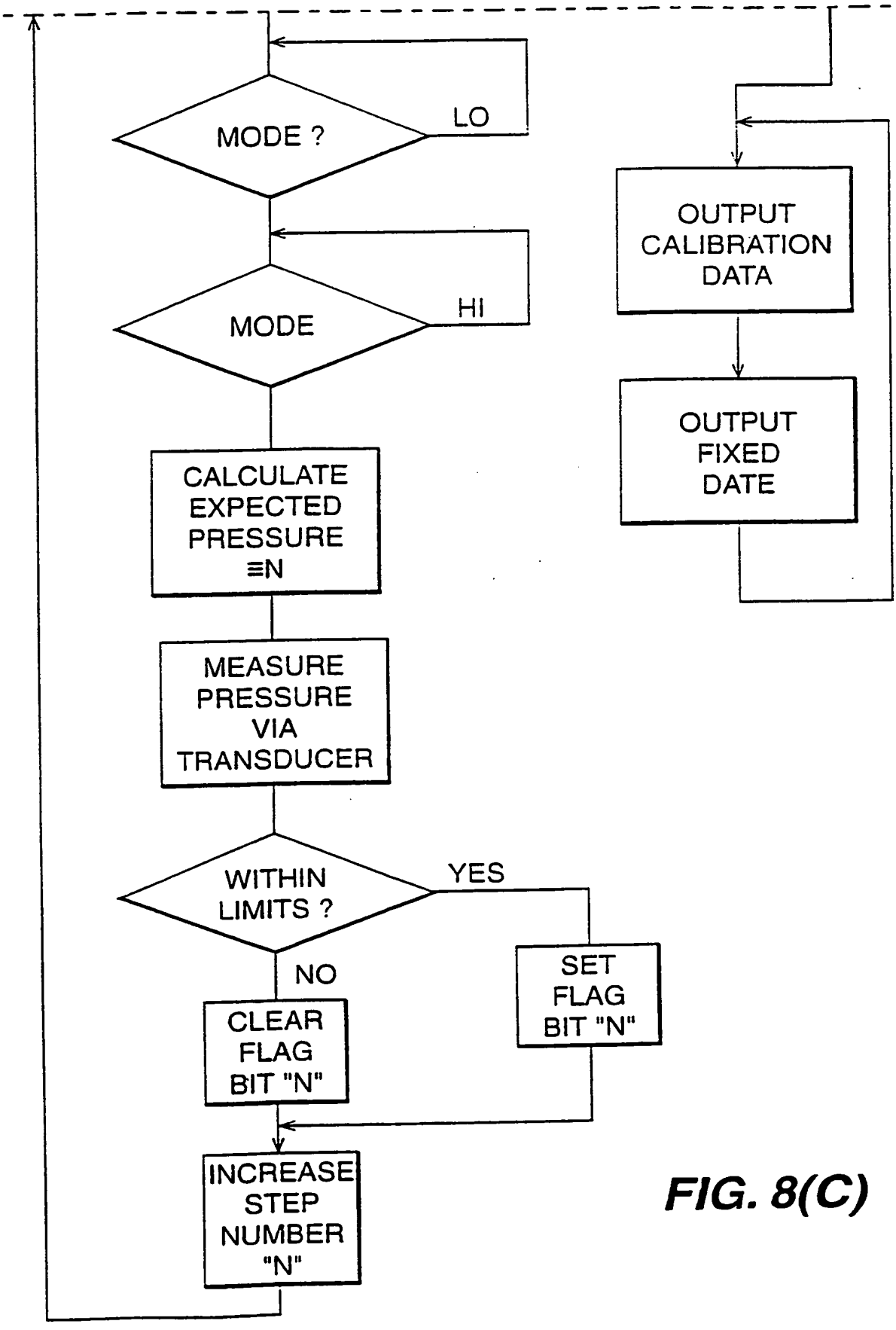
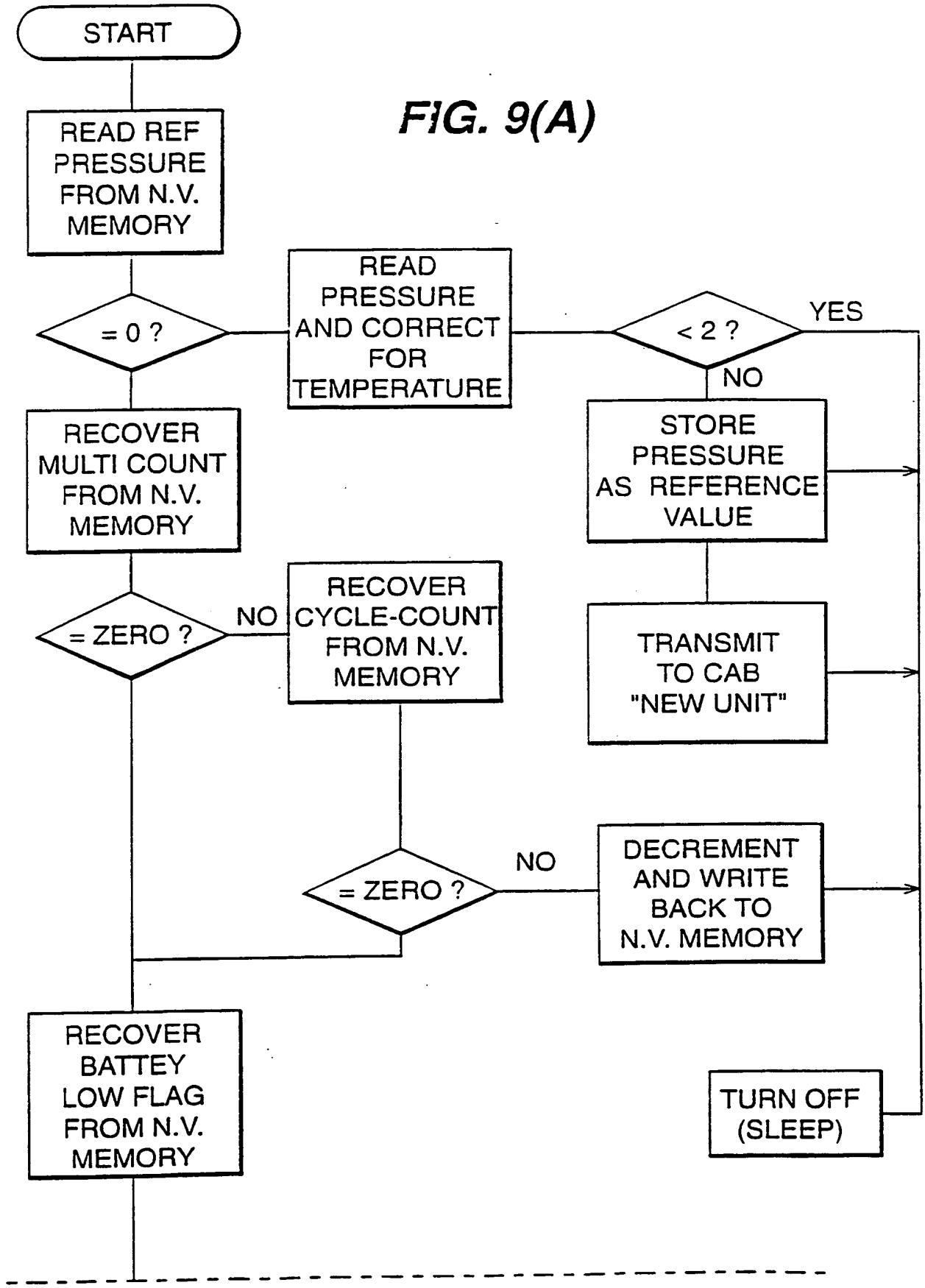

MODE ?
LO
MODE
HI
CALCULATE EXPECTED PRESSURE ≡N
MEASURE PRESSURE VIA TRANSDUCER
WITHIN LIMITS ?
YES
NO
CLEAR FLAG BIT "N"
SET FLAG BIT "N"
INCREASE STEP NUMBER "N"
OUTPUT CALIBRATION DATA
OUTPUT FIXED DATE

FIG. 8(C)

FIG. 9(A)


START
READ REF PRESSURE FROM N.V. MEMORY
= 0 ?
READ PRESSURE AND CORRECT FOR TEMPERATURE
< 2 ?
YES
NO
RECOVER MULTI COUNT FROM N.V. MEMORY
STORE PRESSURE AS REFERENCE VALUE
= ZERO ?
NO
RECOVER CYCLE-COUNT FROM N.V. MEMORY
TRANSMIT TO CAB "NEW UNIT"
= ZERO ?
NO
DECREMENT AND WRITE BACK TO N.V. MEMORY
RECOVER BATTEY LOW FLAG FROM N.V. MEMORY
TURN OFF (SLEEP)

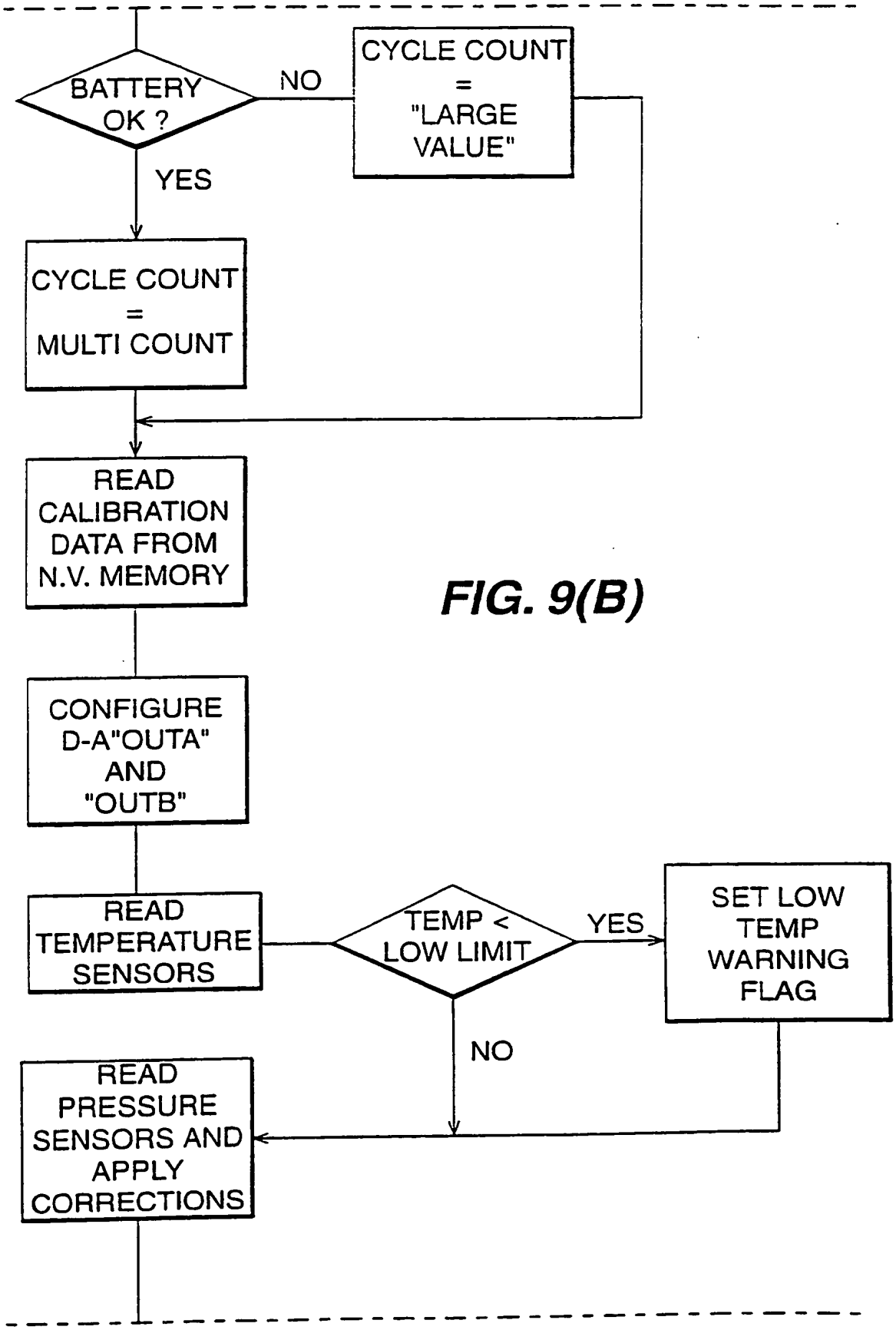

BATTERY OK ?
NO
CYCLE COUNT = "LARGE VALUE"
YES
CYCLE COUNT = MULTI COUNT
READ CALIBRATION DATA FROM N.V. MEMORY
CONFIGURE D-A"OUTA" AND "OUTB"
READ TEMPERATURE SENSORS
TEMP < LOW LIMIT
YES
SET LOW TEMP WARNING FLAG
NO
READ PRESSURE SENSORS AND APPLY CORRECTIONS

FIG. 9(B)

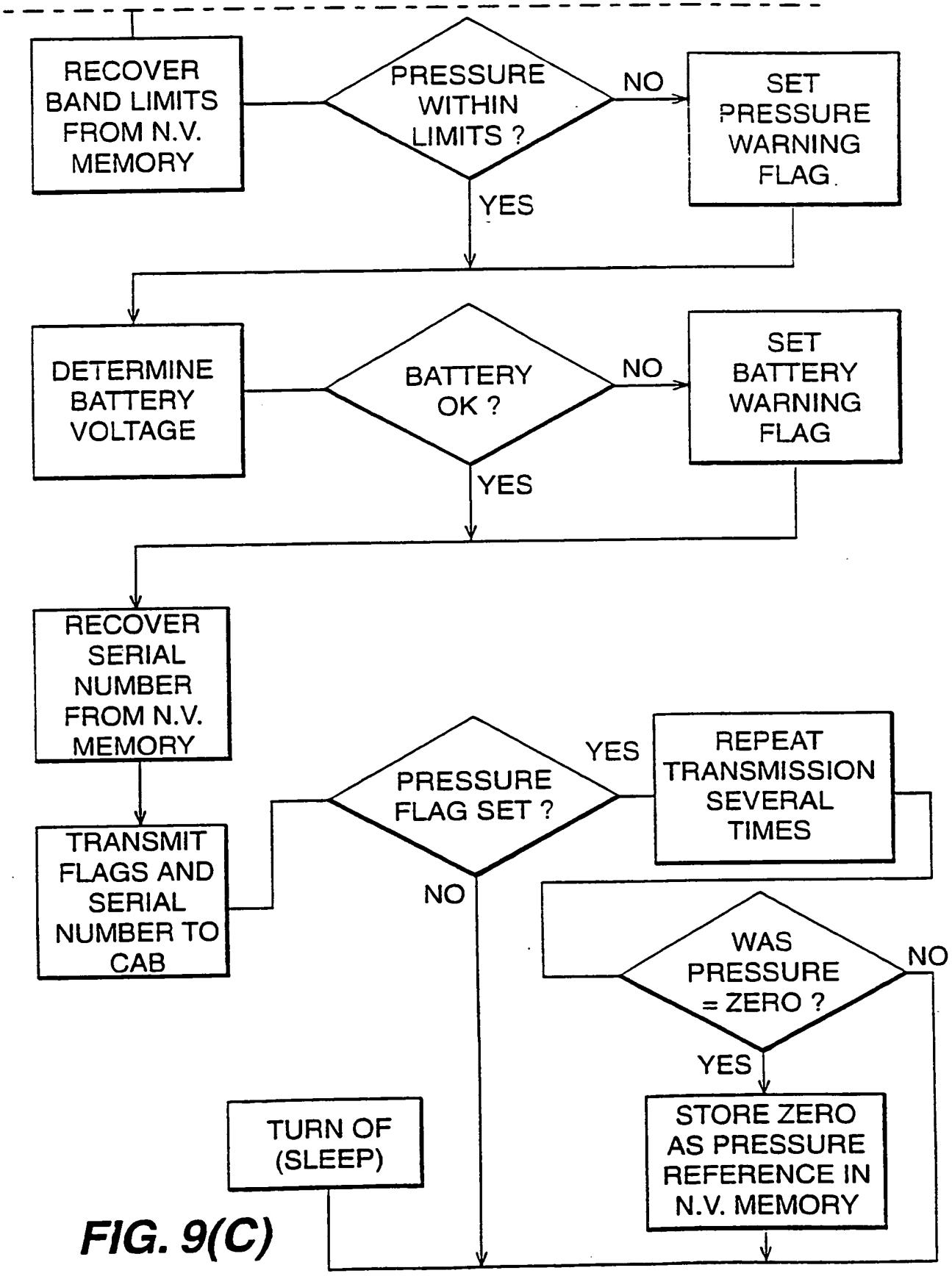

RECOVER BAND LIMITS FROM N.V. MEMORY
PRESSURE WITHIN LIMITS ?
NO
SET PRESSURE WARNING FLAG
YES
DETERMINE BATTERY VOLTAGE
BATTERY OK ?
NO
SET BATTERY WARNING FLAG
YES
RECOVER SERIAL NUMBER FROM N.V. MEMORY
TRANSMIT FLAGS AND SERIAL NUMBER TO CAB
PRESSURE FLAG SET ?
YES
REPEAT TRANSMISSION SEVERAL TIMES
NO
WAS PRESSURE = ZERO ?
NO
YES
STORE ZERO AS PRESSURE REFERENCE IN N.V. MEMORY
TURN OF (SLEEP)

FIG. 9(C)

FIG. 10

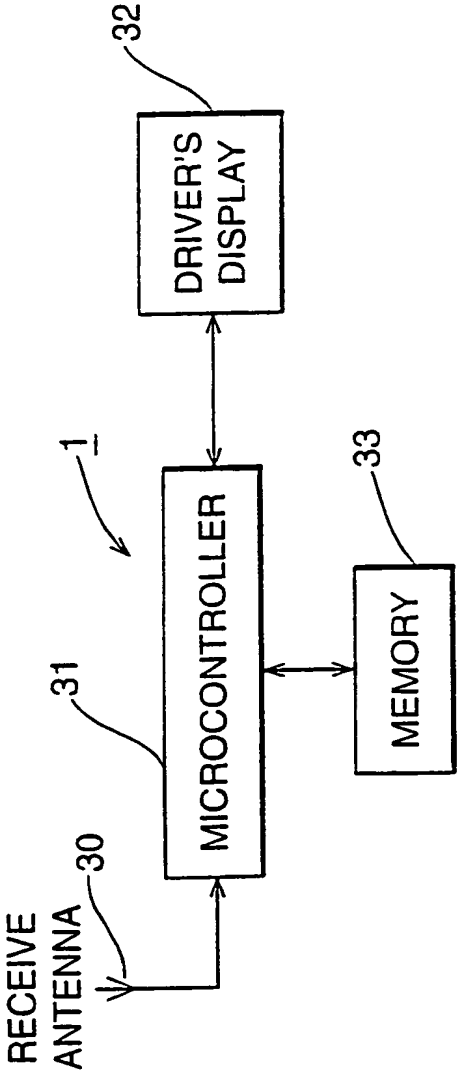
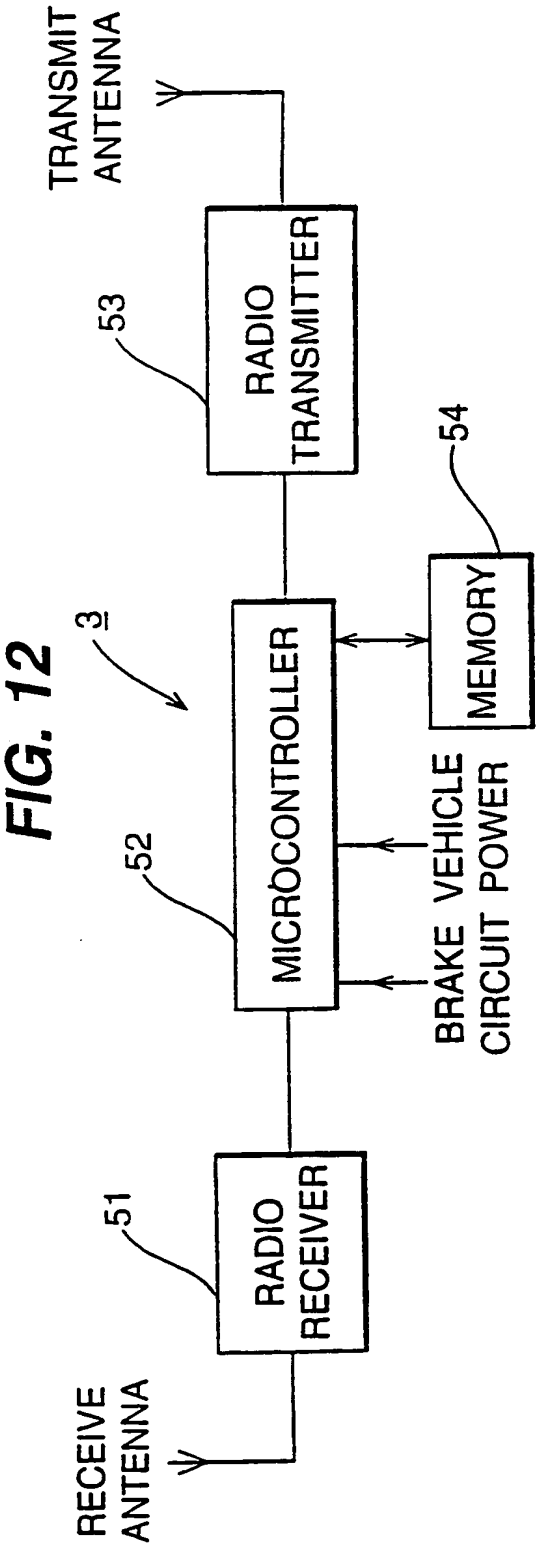

RECEIVE ANTENNA
30
MICROCONTROLLER
31
1
DRIVER'S DISPLAY
32
MEMORY
33

FIG. 12


TRANSMIT ANTENNA
RADIO TRANSMITTER
53
MICROCONTROLLER
52
3
MEMORY
54
BRAKE VEHICLE CIRCUIT POWER
RADIO RECEIVER
51
RECEIVE ANTENNA

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/GB 99/01625

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B60C23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 14620 A (TRUCK TECH CORP) 3 September 1992 (1992-09-03) page 14, line 30 - page 18, line 38 page 20, line 7 - line 37 page 39, line 20 - line 32 page 62, line 1 - line 34 page 84, line 20 - line 26; figures 6,12,18,30,35	1,2,5,6, 8-14
Y	---	3,4,7
Y	WO 96 15919 A (SCHRADER AUTOMOTIVE INC ;MCCLELLAND STEPHEN (GB)) 30 May 1996 (1996-05-30) page 6, line 16 - page 8, line 7; figures -----	3,4,7

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 July 1999	20/07/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hageman, L

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ional Application No
PCT/GB 99/01625

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9214620 A	03-09-1992	US 5231872 A	03-08-1993
		AU 1209692 A	15-09-1992
		CA 2104696 A	22-08-1992
		CA 2221174 A	22-08-1992
		US 5335540 A	09-08-1994
WO 9615919 A	30-05-1996	BR 9408496 A	26-08-1997
		AU 1256795 A	17-06-1997
		EP 0793579 A	10-09-1997
		JP 10508264 T	18-08-1998

PATENT COOPERATION TREATY

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From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

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Prospect House
8 Pembroke Road
Sevenoaks
Kent TN13 1XR
GRANDE BRETAGNE

RECEIVED
9 AUG 2000
E. & F. SEVENOAKS

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	07.08.2000
Applicant's or agent's file reference PJF/G04180PC	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01625	21/05/1999	22/05/1998

Applicant
AUTOMOTIVE TECHNOLOGIES LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Dorpema, A Tel.+49 89 2399-8211

Form PCT/IPEA/416 (July 1992)

16

PATENT COOPERATION TREATY

RECD 09 AUG 2000
WIPO PCT

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PJF/G04180PC		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01625	21/05/1999	22/05/1998
International Patent Classification (IPC) or national classification and IPC B60C23/04		
Applicant AUTOMOTIVE TECHNOLOGIES LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22/11/1999	07.08.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer P. Brachmann Telephone No. +49 89 2399 8869

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01625

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-21	as originally filed			

Claims, No.:

1-9,10 (part)	as originally filed			
10 (part),11-19	as received on	23/06/2000	with letter of	19/06/2000

Drawings, sheets:

1/13-3/13, 5/13-13/13	as originally filed			
4/13	as received on	23/06/2000	with letter of	19/06/2000

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☒ not complied with for the following reasons:

see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 1-12.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-12
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-10
	No:	Claims	11-12
Industrial applicability (IA)	Yes:	Claims	1-12
	No:	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Reference is made to the following documents:

D1: WO 92 14620 A (TRUCK TECH CORP) 3 September 1992 (1992-09-03)

D2: WO 96 15919 A (SCHRADER AUTOMOTIVE INC; MCCLELLAND STEPHEN (GB)) 30 May 1996 (1996-05-30).

To Chapter IV.

See chapter VII.1.

To Chapter V.2.

V.2.1.1. Independent claim 1

Remark: Based on the argumentation of the applicant dated 19.06.2000, the claims 1 and 10 are evaluated as follow:

i) Novelty:

Document D1 shows (see Fig. 4 and 5):

a battery-powered tyre pressure sensor (44), comprising:

- a pressure transducer sensing a pressure of a tyre and providing a tyre pressure signal (Fig. 5, 104 and 120, p. 18, l. 3-15);
- a transmitter (Fig. 4, 86 and p. 16, l.26-35);
- a signal processor connected to the pressure transducer providing a signal dependant on the tyre pressure signal to the transmitter (Fig. 5, 156, p. 20, l. 9-23).

The differences of the subject-matter of independent claim 1 over the document D1 are:

a timing circuit connected to the signal processor which is configured to automatically switch the tyre pressure sensor on periodically for a predetermined interval to measure the tyre pressure and switch off the tyre pressure sensor at all other times to conserve battery power, in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval.

Therefore, the present application does satisfy the criterion set forth in Article 33 (2) PCT because the subject-matter of independent claim 1 is new in respect of prior art as defined in the regulations (Rule 64 (1)-(3) PCT).

ii) Inventive step:

The problem to be solved by the present invention may therefore be regarded as how to decrease the power consumption of the battery-powered tyre pressure sensor known from the prior-art.

Whereas the missing features are not contained in or does be rendered obvious from the state of the art as mentioned in the search report. In the document D1 only the comparators (138, 140, 142, 144) are enable or disable and not the sensors, and no timer is connected to the processor.

Therefore, the subject-matter of claim 1 fulfils the provisions of Art 33 (3) PCT.
The subject-matter of independent claim 10 is a use of a plurality of sensors according to claim 1, and fulfils also the provisions of Art. 33 (2) and (3) PCT even if the other features of the claim 10 are known from the document D1.

V.2.1.2. Dependent claims 2-9

Claims 2-9 depending on claim 1 and having as subject-matter special and advantageous embodiments of the invention according to claim 1, together with its subject-matter, fulfils the provisions of Art. 33 and Rule 6 PCT.

V.2.2.1. Independent claim 11

Document D1 shows (see Fig. 1 or 20):
a transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre (Fig. 20 in combination with p. 62, l. 1-34), the

transponder unit comprising:
- a receiver (46 or 602) receiving the transmitted signals from the individual pressure sensors; a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location.

Document D1, which is considered to represent the most relevant state of the art, differs from the subject-matter of the present claim 11 only in that a transmitter transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

The solution proposed in claim 11 of the present application cannot be seen, at the moment, as involving an inventive step (Article 33(3) PCT) in view of the statement, D1, page 40, l. 17-28, which means for the person skilled in the art that the coded signals are directly transmitted from the trailer to the cab with a respective ID and without using an additional transmitter (transponder).

V.2.2.2. Claim 12 depending on claim 11

Claim 12 depending on claim 11 and having as subject-matter special embodiments of the invention according to claim 11 do not fulfil the provisions of the PCT (Art. 33 and Rule 6 PCT) since their validity is dependent on that of claim 11, which has been denied. Further, the features of claim 12 do not add new features or anything of inventive significance (in the sense of Arts. 33 (2) or (3) PCT) to the subject-matter of claim 11, because its subject-matter seems to be a self evidence for the person skilled in the art.

V.2.3. Industrial applicability

Claims 1-12 fulfils the provisions of Art. 33 (4) PCT, because corresponding systems can be produced and used at least in the automotive industry.

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PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:
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Prospect House
8 Pembroke Road
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GRANDE BRETAGNE

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	18.02.2000
Applicant's or agent's file reference: PJF/G04180PC	**REPLY DUE** **within 3 month(s)** from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01625	21/05/1999	22/05/1998

International Patent Classification (IPC) or both national classification and IPC
B60C23/04

Applicant
AUTOMOTIVE TECHNOLOGIES LIMITED et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I	☒	Basis of the opinion
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☒	Lack of unity of invention
V	☒	Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain document cited
VII	☒	Certain defects in the international application
VIII	☒	Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 22/09/2000.

Name and mailing address of the international preliminary examining authority:
European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer / Examiner
P. Brachmann

Formalities officer (incl. extension of time limits)
Gauert, B
Telephone No. +49 89 2399 8588

and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees:

see separate sheet

3. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this opinion:

☒ all parts.

☐ the parts relating to claims Nos. .

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1,2,5,6,9,10
Inventive step (IS)	Claims	3,4,7,8,11,12,13,14
Industrial applicability (IA)	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Reference is made to the following documents:

D1: WO 92 14620 A (TRUCK TECH CORP) 3 September 1992 (1992-09-03)

D2: WO 96 15919 A (SCHRADER AUTOMOTIVE INC; MCCLELLAND STEPHEN (GB)) 30 May 1996 (1996-05-30).

To Chapter IV.

See chapter VII.1.

To Chapter V.2.

V.2.1.1. Independent claim 1

Document D1 shows (see Fig. 4 and 5):
a battery-powered tyre pressure sensor (44), comprising:
- a pressure transducer sensing a pressure of a tyre and providing a tyre pressure signal (Fig. 5, 104 and 120, p. 18, l. 3-15);
- a transmitter (Fig. 4, 86 and p. 16, l.26-35);
- a signal processor connected to the pressure transducer providing a signal dependant on the tyre pressure signal to the transmitter (Fig. 5, 156, p. 20, l. 9-23);
- a timing circuit connected to the signal processor which is configured to automatically switch the tyre pressure sensor on periodically for a predetermined interval to measure the tyre pressure and switch off the tyre pressure sensor at all other times to conserve battery power, in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval (Fig. 6, p. 21/23, l. 15/3).

Therefore, the present application does not satisfy the criterion set forth in Article 33 (2) PCT because the subject-matter of independent claim 1 is not new in respect of prior art as defined in the regulations (Rule 64 (1)-(3) PCT).

V.2.1.2. Claims 2-9 depending on claim 1

Claims 2-9 depending on claim 1 and having as subject-matter special embodiments of the invention according to claim 1 do not fulfil the provisions of the PCT (Art. 33 and Rule 6 PCT) since their validity is dependent on that of claim 1, which has been denied.

Further, the features of the following claims do not add new features or anything of inventive significance (in the sense of Arts. 33 (2) or (3) PCT) to the subject-matter of claim 1, the features being -at least per se - known from the documents listed below:
- claim 2: D1, Fig. 5, 158 (ROM);
- claim 3: D2, p. 7, l. 10-13;
- claim 4: D2, p. 5, l. 17-20;
- claim 5: D1, p. 17, l. 15-25;
- claim 6: D1, p. 39, l. 20-32;
- claim 7: D2, p. 7, l. 2-7;
- claim 8: self-evident for the person skilled in the art, especially in this application where the saving of the battery energy is very important;
- claim 9: D1, Fig. 1 and 2.

V.2.2. Independent claim 10

Notice: even if the claim 10 is linked to claims 1 to 9 (use of the battery-powered tyre pressor sensor as defined by these claims), it is considered to be an independent claim.

Document D1 shows (see Fig. 1):
a remote tyre pressure monitoring system for mounting on a vehicle, comprising a plurality of tyre pressure sensors according to any preceding claim in combination with a cab unit being mounted within the vehicle cab, the cab unit (42) comprising:
- a receiver (46) detecting transmissions from the respective transmitters of the tyre pressure sensors; and,
- a display providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors (p. 13, l. 20-25).

Therefore, the present application does not satisfy the criterion set forth in Article 33 (2)

PCT because the subject-matter of independent claim 10 is not new in respect of prior art as defined in the regulations (Rule 64 (1)-(3) PCT).

V.2.3.1. Independent claims 11 and 12

Document D1 shows (see Fig. 1 or 20):
a transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre (Fig. 20 in combination with p. 62, l. 1-34), the transponder unit comprising:
- a receiver (46 or 602) receiving the transmitted signals from the individual pressure sensors; a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location.

Document D1, which is considered to represent the most relevant state of the art, differs from the subject-matter of the present claim 11 only in that a transmitter transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

The solution proposed in claim 11 of the present application cannot be seen, at the moment, as involving an inventive step (Article 33(3) PCT) in view of the statement, D1, page 40, l. 17-28, which means for the person skilled in the art that the coded signals are directly transmitted from the trailer to the cab with a respective ID and without using an additional transmitter (transponder).
The subject-matter of the independent claim 12 is a use of the transponder unit according to claim 11, and therefore also not considered to be inventive because the further features of claim 12 are already known from the document D1, especially from Fig. 1.

V.2.3.2. Claims 13-14 depending on claim 12

Claims 13-14 depending on claim 12 and having as subject-matter special embodiments of the invention according to claim 12 do not fulfil the provisions of the

PCT (Art. 33 and Rule 6 PCT) since their validity is dependent on that of claim 12, which has been denied.

Further, the features of the following claim do not add new features or anything of inventive significance (in the sense of Arts. 33 (2) or (3) PCT) to the subject-matter of claim 12, the features being -at least per se - known from the document D1 and chapter V.2.1. for claim 14.

To Chapter VII.

VII.1. In the claims

The subject-matter of independent claims 1 and 10 is already known and the subject-matter of independent claims 11 and 12 does not seem to be inventive (see the grounds for this objection in chapter V.2.). The requisite unity of invention (Rule 13.1 PCT) therefore no longer exists because a technical relationship involving one or more of the same or corresponding special technical features in the sense of Rule 13.2 PCT does not exist between the subject-matter of the following groups of independent claims:
- claims 1 and 10,
- claims 11 and 12.

Therefore, in this case it seems to be appropriate to delete claims 1 and 10.

All the independent claims are not in the two-part form according to Rule 6.3(b) PCT, which in the present case seems to be appropriate, with those features known in combination from the prior art (document D1) being placed in the preamble (Rule 6.3(b)(I) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

If the applicant is of the opinion that a two-part form of all independent claims would be inappropriate, he is invited to provide reasons in his reply. In addition, the applicant should ensure that it is **completely clear** from the description which features of the subject-matter of these claims known from the closest prior art document D1; see PCT Guidelines PCT/GL/3 III, 2.3a.

The features of all pending claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT). This applies to the preamble and the characterising portion.

VII.2. In the description

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not briefly discussed in the description, nor is this document identified therein.

If the applicant intends to file new claims, he will have to bring the description into conformity with these claims; care should be taken during revision, especially of the introductory portion including any statement of problem or advantage, not to add subject-matter which extends beyond the content of the application as originally filed, (Article 34 (2) (b) PCT).

It is suggested that a short reference be made to the claims in the description (Art. 6 PCT: Support by the description).

In the description on page 11, l. 16, the reference sign is 14 instead of 15.

To Chapter VIII.

VIII.1. Clarity

The use of the word "for" in the claims has no limiting effect and renders therefore the scope of protection of the present application unclear. In order to make clear that the features behind this word are not facultative it should be replaced by a more appropriate one (Art. 6 PCT).

VIII.2. General statement with regard to the subject-matter of the present application

At present, it is not apparent which part of the application could serve as a basis for a new claim which would satisfy the criteria set forth in Article 33 (1) PCT. Should the ap-

plicant nevertheless regard some particular matter as suitable an independent claim including such particular matter should be filed taking account of Rule 6.3 b) PCT. The applicant should also indicate in the letter of reply the difference vis-à-vis the state of the art and the significance thereof.

VIII.3. General requirements for amendments

The applicant is requested to file amendments by way of replacement **of complete** pages. Additional pages should be numbered e.g. 1a, 1b etc. He should also take into account the requirements of Rule 66.8 PCT. In particular, two additional sets of fair copies of the amendments should be provided.

The attention of the applicant is drawn to the fact that the application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as filed, Article 34 (2) (b) PCT.

In order to expedite further examination the applicant is requested to indicate with your reply the locations in the application as originally filed of the passages forming a basis for the amendments. Especially when the original disclosure of the amendments is not absolutely obvious, such indications should be provided by the applicant.

In view of the restricted time limits of the procedure and in order to achieve an economic procedure, the applicant should respond in his own interest **as soon and as comprehensively as possible**.

To Chapter VII.

VII.1. In the claims

The subject-matter of independent claims 1 and 10 and the subject-matter of independent claims 11, 13 and 16 have no technical relationship involving one or more of the same or corresponding special technical features in the sense of Rule 13.2 PCT does not exist between the subject-matter of the following groups of independent claims:
- claims 1 and 10 (use of a plurality of sensors according to the independent claim1),
- claims 11, 13 and 16.

Therefore, in this case it seems to be appropriate to modify claim 11, 13 and 16 to limit their scope of protection to the use of sensors according to the independent claim 1 in order to have the above-mentioned common technical relationship for the whole invention in order to fulfil the requirements of unity of invention according to Rule 13.1 PCT.

All the independent claims are not in the two-part form according to Rule 6.3(b) PCT, which in the present case seems to be appropriate, with those features known in combination from the prior art (document D1) being placed in the preamble (Rule 6.3(b)(I) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

The features of all pending claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT). This applies to the preamble and the characterising portion.

VII.2. In the description

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not briefly discussed in the description, nor is this document identified therein.

cab unit for mounting within the vehicle cab, the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors; and,

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

11. A transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre, the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors;

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location; and,

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

12. A transponder unit according to claim 11, further comprising a memory to store a unique identification code to identify the transponder unit.

13. A remote tyre pressure monitoring system comprising a transponder unit according to claim 11 or 12, in combination with a cab unit, the cab unit comprising:

a receiver for receiving the coded signal from the transponder unit;

a signal processor for detecting and decoding the coded signal; and,

a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

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14. A remote tyre pressure monitoring system according to claim 13, further comprising a vehicle trailer on which the transponder unit is mounted.

15. A remote type pressure monitoring system according to claim 13 or 14, in which the remote tyre pressure sensors are tyre pressure sensors according to any of claims 1 to 9.

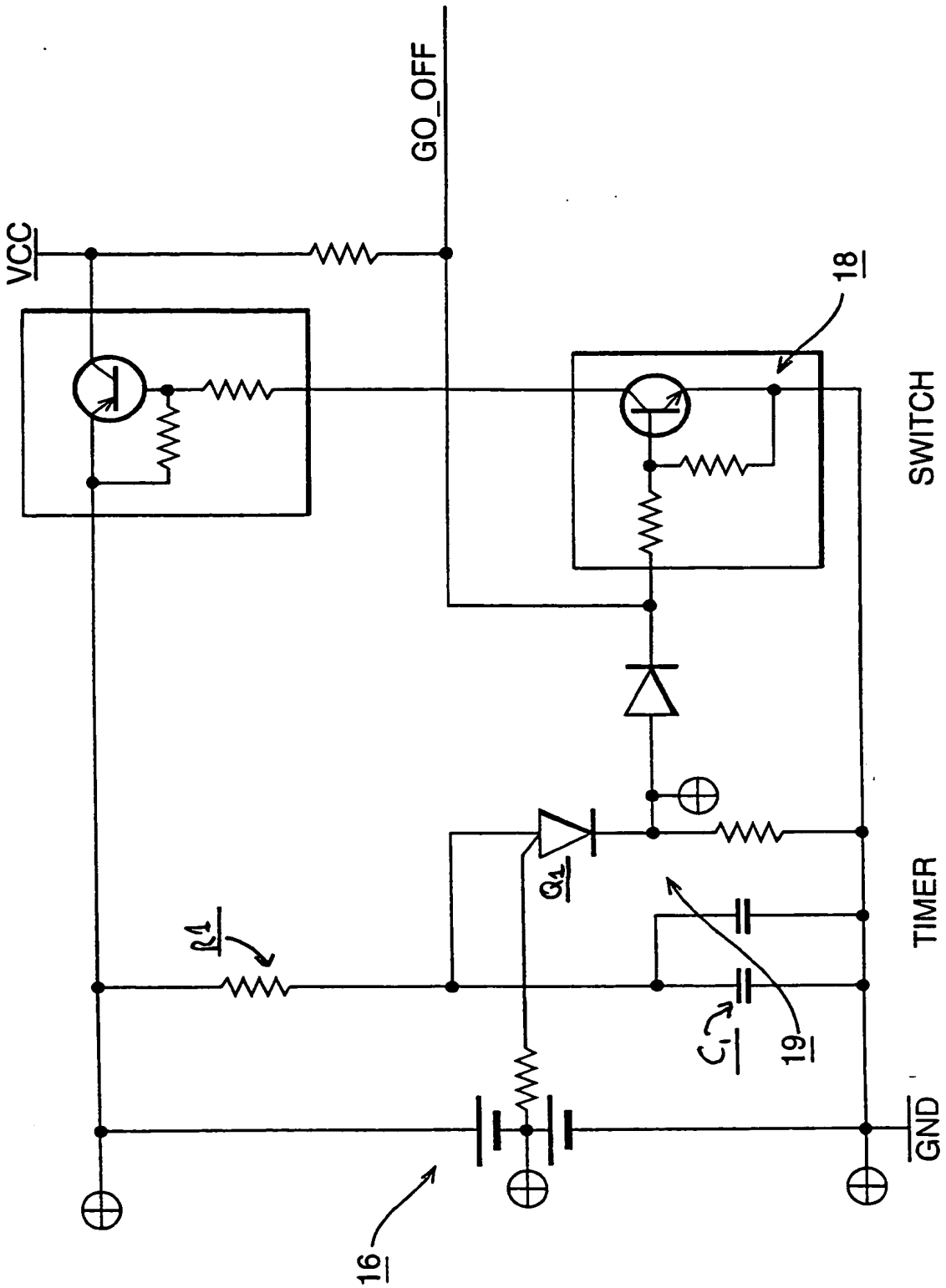
16. A vehicle comprising a cab unit and a trailer unit connectable to the cab unit, comprising a remote tyre pressure monitoring system according to any of claims 13 to 15.

17. A vehicle according to claim 16, in which the transponder unit is responsive to transmit an identification signal to the remote receiver when power is first supplied to the transponder unit.

18. A vehicle according to claim 17, in which power is supplied to the transponder unit by activation of the vehicle brake light line.

19. A vehicle according to any of claims 16 to 18, wherein the receiver of the transponder unit has a processor programmed to recognise transmissions from sensors connected to wheels of the trailer and ignore all others.

FIG. 4



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532 Rec'd 20 NOV 2000

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OUR REFERENCE
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PLEASE REPLY TO
SEVENOAKS OFFICE

19 June 2000

International Preliminary
Examining Authority
The European Patent Office
D-80298 Munchen
GERMANY

Via Facsimile
Confirmation by Post

Dear Sirs

Re: International Patent Application Number PCT/GB99/01625
Automotive Technologies Limited

In response to the Written Opinion dated 18 February 2000, we are filing herewith amended pages 24 and 25 in triplicate and ask that these replace the corresponding pages presently on file.

The Examiner will see that new claims 12 and 16 to 19 have been added relating to the powering and operation of the transponder unit. Support for the features in these claims can be found at page 19, lines 11 to 15 and page 20, lines 10 to 15 respectively.

In paragraph V.2.1.1. of the Official Letter, the Examiner alleges that claim 1 of the present application lacks novelty in view of the disclosure of International Patent application number WO92/14620 (D1). We deny this.

The present invention provides a battery powered tyre pressure sensor having a timer circuit which is configured to periodically actuate a switch and thereby connect the pressure sensor to the associated battery to turn the tyre pressure sensor on for a predetermined interval (and claim 1 is restricted to this feature). **In other words, at all other times, the battery is not connected to any power-drawing circuits apart from the timer.** The current drawn by the timer (and therefore the sensor in stand by mode) is of the order of 600 nA (an explanation of how this value is obtained is provided below). The current drawn by the sensor when connected to the battery is of the order of 2 mA giving a ratio of approximately 3300:1 between power consumption when the sensor is connected and unconnected to the battery.

A system such as this enables a substantially larger battery life to be obtained for a typical battery such as the Varta CR1620-3V Lithium Manganese Dioxide battery. In addition, since the life of the battery is extended by this system, a smaller battery can be used which enables the external dimensions of the pressure sensor to be reduced.

In contrast to this, document D1 discloses a tyre pressure sensor having a control circuit which is controlled to be in either a high-power mode in which the sensor is either actively sampling the pressure and transmitting a signal or in a low-power "sleep" mode. **This device does not have a "timer circuit which is configured to periodically actuate a switch and thereby connect the pressure sensor to the associated battery to turn the tyre pressure sensor on for a predetermined interval", as required by claim 1.** Accordingly, it is not an anticipation of claim 1. Furthermore, it is worth noting that the architecture of D1 provides a power ratio of 3300:12 since the sensor is *not* disconnected from the battery (typical stand by current = 7.5 μA, typical operational current = 2 mA).

Therefore in comparison with the present invention 12 times more power is used by the device of D1 when the sensor is supposedly off. Thus, for a battery of equal size, the battery life is substantially reduced. Of course, if a larger battery is used to compensate for this the external dimensions of the sensor must be commensurately increased which is undesirable.

A copy of Figure 4 of the present application is attached with components C1, Q1 and R1 labelled. Typical values for R1 and C1 would be 8.2 MΩ and 10 μF respectively. Values of C1 and R1 of these magnitudes would give a wake up event for the sensor approximately every 60 seconds depending upon component tolerances. The average current drawn in the sleep mode of the sensor is calculated using the equation $I=CV_p/t$ [equation 1], in which C is the capacitance of C1, I is the current in amps drawn by the device and t is the time in seconds between wake up events (approx. 60 from above). The voltage V_p will be approximately 3.28V as this is the value of the voltage across C1 when transistor Q1 triggers. The value for the current I, can then be deduced from equation 1 above to be approximately 512.5nA. Once leakage currents in the device have been taken into consideration the value of 600nm mentioned above is obtained.

A typical micro-controller has a "sleep" mode in which program operation is suspended and power consumption is reduced to a minimum. An internal or external event can be used to "wake" the microprocessor and resume program operation. Usually the circuit will be arranged such that all components which are not required at any instant, are put in to low power mode as well. However, all electronic components use a small amount of stand by current even in sleep mode. It is this stand by current which causes most problems in circuits, which "sleep" for very long periods relative to their operational time. A situation occurs where more battery life is "wasted" in sleep mode than is usefully used by the processor executing its program.

The present invention provides a solution to the problems associated with the powering of such devices where it is necessary to ensure the longest possible life of a battery. This is achieved with the use of an external power switch to isolate the processor and other components completely from the battery during "sleep" periods and only reconnect them when they are required. The advantage of this approach is that the only component consuming power during "sleep" periods is the timer circuit. Thus, the present invention teaches away from methods such as those taught by D1 and does not use a control signal to the processor but rather disconnects the processor from the power source entirely when it is not actively sampling the pressure and/or transmitting a signal to the cab-unit. This arrangement ensures that the only power required in a low-power mode is that to drive the timer which is substantially less than that required to drive a conventional processor in sleep mode.

We therefore submit that the present invention is patentably distinguished over the cited prior art and request that the Examiner withdraws his objections.

Yours faithfully

Peter Finnie

REPLACED BY

cab unit for mounting within the vehicle cab. the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors: and.

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

11. A transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres. wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre. the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors:

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location: and.

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

12. A remote tyre pressure monitoring system comprising a transponder unit according to claim 11. in combination with a cab unit. the cab unit comprising:

a receiver for receiving the coded signal from the transponder unit;

a signal processor for detecting and decoding the coded signal: and.

a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

13. A remote tyre pressure monitoring system according to claim 12. further comprising

a vehicle trailer on which the transponder unit is mounted.

14. A remote tyre pressure monitoring system according to claim 12 or 13, in which the remote tyre pressure sensors are tyre pressure sensors according to any of claims 1 to 9.

FIG. 4